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IN DEFENSE OF THE SUGAR BEET INDUSTRY OF THE WESTERN UNITED STATES*

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The beet-sugar industry of the United States is almost entirely a development of the twentieth century. From its inception as a major agricultural industry, it has been the center of bitter controversy arising from three essential characteristics of its organization. First, its dependence upon government protection, in the form of tariffs and subsidies, against foreign competition. Second, its industrial organization, which necessitates large unit investment and industrial plant. Third, its reliance on imported foreign workers to carry on the arduous "stoop labor" that others have been reluctant to perform.

The advocates of free trade have damned the industry as epitomizing all the evils of nationalism. They claim that the country at large has been penalized for the protection and enrichment of a relatively small and regionalized industry. Others have damned it for its unethical treatment of imported labor, which has led to social segregation and class intolerance. These attacks have centered almost exclusively on the western sugar-beet states. Examination of the industry and its problems has convinced me that many of the criticisms lack foundation and that many of the early objectionable features of the industry have been corrected. Some aspects of the industry are still open to criticism and need correction. However, these adverse features are not restricted solely to the beet-sugar industry, but are shared in varicus degrees by almost every agricultural industry in this country. The entire question is too complex to be properly covered in a short paper. The following discussion will be limited to an analysis of some of the major criticisms directed against the industry.

WORLD PRODUCTION OF SUGAR

From the middle of the nineteenth century to the beginning of the first world war sugar production increased at an average rate of 3.5 percent per year. Following the peak year of 1913-1914, when 20,997,000 short tons were refined, world production slumped. Since then it has fluctuated considerably, and in 1946-1947 totaled 20,817,000 tons. Beet sugar was a late starter in the field, but by the end of the last century, under strong tariff protection, it made up 64 percent of the world's total. The first world war seriously disrupted the beet-sugar industry all over the world, and in 1919-1920 it contributed only 21 percent of the total sugar supply. Since then, beet-sugar production, under reduced protection, has made a slow recovery and contributed 44 percent of the total in 1946-1947.

PRODUCTION AND CONSUMPTION IN THE UNITED STATES

The United States, with a per capita consumption of 97 pounds per year, is the world's greatest consumer of sugar. In 1939, the last normal year, we consumed 6,945,-000 tons, or about 22 percent of the total. It is estimated that in 1948 we shall use

* Presidential address of the Association of Pacific Coast Geographers, Berkeley, California, June 24, 1948.

7,000,000 short tons, of which 26 percent has been allocated to continental beet sugar and seven percent to the continental cane-sugar producers.

ENVIRONMENTAL REQUIREMENTS OF SUGAR BEETS

An oft-repeated but untrue criticism is that we are capable of producing only a small percentage of the sugar required by the nation. Sugar beets can be grown successfully throughout a large portion of the United States, under a considerable range of climatic and edaphic conditions. In the final analysis, beet sugar is simply a combination of carbon dioxide, water, and sunshine. Beets require much moisture during their growing season, and although they can withstand drought as well as or better than most crops, a deficiency of soil moisture is reflected in reduced yields. Beets are grown under normal rainfall east of the 20-inch isohyet, but in the arid and semi-arid western states successful growth demands supplemental irrigation. Under irrigation, however, the beets can be supplied with the optimum quantity of water for their best development. Beets are favored by a long and moderately cool growing season. There is a remarkable correlation between the distribution of sugar factories and the belt between the mean summer isotherms of 67 degrees and 72 degrees Fahrenheit. As the beet stores most of its sugar in the latter part of the season, the long, rainless, and sunny days of the western states are ideal.

The beet is adaptable to most good soils, and is rather tolerant toward soil reaction, since it will produce well on either fairly acid or alkaline soils. In general, sandy loams with a slightly alkaline reaction are preferred. The main requirements seem to be a soil having good depth, a rather high organic content, adequate drainage, and high ability to retain moisture.

REGIONS OF SUGAR-BEET PRODUCTION IN THE UNITED STATES

Sugar beets are produced in three regions of the United States, which are fairly distinct in climate and in the competitive relations of sugar beets with other crops. The total acreage is divided among them approximately as follows: (1), about 25 percent in the humid north central states; (2), about 55 percent in the mountain states, Colorado, Wyoming, Montana, Utah, Idaho, and the western parts of Kansas, Nebraska, and South Dakota; and (3), about 20 percent in the Pacific Coast states, California, Oregon, and Washington. Normally between 750,000 and a million acres are planted in beets. The average yield is about twelve tons of beets per acre harvested. The average yield of sugar is 3,500 pounds per acre, or 295 pounds of sugar per ton of beets.

It is not difficult to find suitable land on which to grow this crop. The United States Department of Agriculture estimates that there are 274,000,000 acres in the country that are suitable for successful beet culture. The growing of beets on only one out of every 58 acres of this total would supply the entire sugar demand of the country in 1948, without recourse to any imports or dependence on mainland cane sugar. This would require a quadrupling of our present acreage in beets. It is obvious, therefore, that the problem of beet-sugar production is not availability of land suitable for beets; it concerns, rather, the relative cost of producing beet sugar in comparison with the cost of producing cane sugar in and transporting it from tropical lands. It is the discrepancy between these costs that has necessitated federal protection of domestic production.

FEDERAL PROTECTION

The history of the domestic sugar industry is a history of the commercial philosophy of our nation. Born of tariffs and bounties, the sugar-beet industry has grown to lusty maturity, but still rests on a basis of protection. This is not a unique situation, since both our foreign and home markets and all industries concerned in them are directly or

indirectly dependent on foreign tariffs. The beet-sugar industry is not a simple, isolated economic problem, but is involved with other social, economic, and political problems that underlie our whole national structure. We cannot change our domestic tariff policy without entailing losses greater than even the most ardent free-trader would favor. The solution of the intricate problems of the sugar industry involves the contemporaneous solution of similar and interrelated problems in other fields.

Protection for domestic sugar has taken the form of various types of tariffs, bounties, subsidies, and production quotas. Prior to 1934 the most common form was the import duty. The rate was placed at a level high enough to overcome the disadvantage of domestic sugar in competition with cheaper tropical cane sugar and to prevent the dumping of sugar on the American market below cost. No detailed recent study of the costs of producing tropical sugar is available. However, it was found in 1934 that cane sugar could be produced at a cost approximately 1.5 cents per pound below the cost of domestic beet and cane sugar. The difference in cost has varied from time to time, and as a result the tariff rate has varied considerably, from 75 cents to as much as $3.50 per hundred pounds on imported raw and refined foreign sugar. Between 1903 and 1934, Cuba was given a preferential reduction of 20 percent from the full duty.

In more recent years, protection has taken the form of production quotas allotted to the various sugar-producing regions, both foreign and domestic, and of direct payment of subsidies to domestic producers. The Sugar Act of 1948, for example, provides that the Secretary of Agriculture, in December, shall determine the sugar requirements of the United States for the succeeding year. The amount determined shall be made at a level which, through the "law of supply and demand," will provide an adequate supply of sugar at prices reasonable to the consumer, and at the same time fairly and equitably maintain and protect the welfare of the domestic sugar industry.

The Secretary determined that 7,000,000 short tons would be required in 1948. Of this total, 4,268,000 tons were apportioned among the six domestic, continental and insular, sugar areas. Approximately 1,800,000 tons were allotted to Cuba. Owing to the failure of the Philippines to meet their quota this year, a slight revision has been made in the apportionment of the total, and the domestic beet-sugar producers have now been allotted a total of 1,847,000 tons.

Under the Sugar Act, the federal government levies on the refiner a processing tax of 53.5 cents on each hundred pounds of refined sugar, foreign and domestic alike. This refiners' tax will produce an annual revenue of nearly $75,000,000, which is essentially the revenue formerly derived from duties levied on imported sugar. The Act further provides that direct subsidy payments by the federal government to the domestic farmers for growing beets or cane be made on a sliding scale, in inverse ratio to the amount of commercially recoverable sugar produced per farm unit. This plan was devised in an effort to encourage the production of beets and cane on a small scale as an adjunct to other farm crops, and to discourage corporate production. Sugar beets are generally produced on small acreages, and as a result the farmer receives the maximum conditional payment of 80 cents per hundred pounds of recoverable sugar. This is equivalent to a bounty of about $2.35 per ton, or about $28.00 per acre of beets. Plantations that produce more than 30,000 tons of commercially recoverable sugar receive a payment of only 30 cents per hundred pounds of sugar.

Is the Beet-Sugar Industry a "Trust-Monopoly"?

The accusation that the beet-sugar corporations represent a vicious trust-monopoly, supported by federal protection, is frequently given as a basic reason for the discontinuance of public support to the industry. It is true that large corporate enterprise is involved, because for the most efficient development of the industry large-scale operation,

involving expensive plant and large capital outlay, is required. Small sugar factories are not economical. But to stigmatize the entire industry as a monopoly, exercising all the anti-social prerogatives associated with the term, is unfair. If the accusation were true, it would be more sensible to invoke the anti-trust laws than to recommend discontinuance of the entire industry. To exercise monopolistic control, corporations would have to control both production and processing. In the beet-sugar industry, three factions are involved in a rather unique combination. These factions are so suspicious of one another that any attempt on the part of one to gain monopolistic control would immediately be challenged by the other two. In the first place, the sugar processors cannot make a profit, — cannot, in fact, survive — without a guaranteed minimum supply of beets. Without the cooperation of the growers, they are doomed. In the second place, beet-growers cannot economically raise beets without a fair share of the net profits of the industry. It behooves both to play fair with each other. But if the processor claims too large a share of the net profits, the grower is not compelled to grow beets. Sugar-beets have such a narrow advantage over many competing crops that if the farmer feels that he is being unfairly treated he may refuse to grow beets and still survive on the profits from other crops. In the third place, tropical sugar refiners and advocates of free trade keep a close scrutiny of the profits of the beet-sugar industry. Through their political strength, they can prevent any obvious combination of the beet-growers and the beet-sugar processors. Any attempt of this nature would be immediately reflected in the structure of federal support of domestic sugar.

Unlike other important field crops, the sugar beet is almost always grown under yearly contract with the factory. Such contracts carry stipulations concerning the acreage to be grown, practices of cultivation and harvesting, and delivery of the crop. In most areas the contract guarantees the farmer a flat minimum tonnage rate for beets of a stated grade delivered to the factory. In addition, the net profits from the year's activity are prorated between the factory and the growers. It is this assured income that makes the sugar beet so popular with farmers. Many of them depend on their beet crop to pay a substantial part of the general farm expenses, including taxes, interest on borrowed money, water assessments, and purchases of machinery and livestock.

Opponents of the beet-sugar industry claim that protection and subsidy of the industry destroy the trade balance that permits tropical producers of cane sugar to purchase food products and manufactured goods produced in this country. There is no argument against this position. Yet one must question the ultimate advantage of such trade, if through its promotion a larger and more stable market for the same and similar products within our national limits were crippled or destroyed. No exact formula has been devised to measure the economic value of one industry isolated from the whole economy of a region. The determining factor must be the extent and variety of its direct and indirect benefits to society. There is no doubt that the irrigated sugar-beet areas of our West, with their supporting communities and activities, are heavier and more dependable "importers" of food products and manufactured goods originating elsewhere in the country than are the cane-sugar producers across the sea.

This is but a part of the problem, since sugar-beet production creates a cycle of industrial, commercial, and transportational activities that yields wide domestic benefits and adds to buying power. The sugar-beet industry utilizes many facilities of transportation, estimated to cost at least $35.00 per acre of beets, which is much greater than is required by other crops. Thousands of additional railway workers and truck drivers are employed to provide transportation for the industry, the cost of which in normal years amounts to more than $35,000,000.

The stimulating effect on other industries within the beet-growing areas has been suggested above, but the suggestion should be amplified. Beet-sugar refining requires large amounts of limestone, and thus supports an important local quarrying industry.

For every ton of sugar manufactured, one ton of coal must be mined and one-half ton of limestone quarried; in 1945 these requirements amounted to 1,194,000 tons of coal and 597,000 tons of limestone. Coal mining and generation of electric power are stimulated. The larger population and the increased purchasing power associated with the beet-sugar industry are reflected in the quality of commercial concerns, schools, churches, roads, and the like, within the sugar-producing communities. Agriculture has become dependent on the system of exchange and thus upon the conditions of industry. The interdependence between agriculture and the whole economy is very complete. The technology associated with beet culture is an essential part of the industrialization of the West.

The beet industry often criticized as an inefficient "hothouse" activity, which without protection could not withstand the competition of cane sugar. It is true that in comparison with other field crops beets are expensive to grow and require much hand labor. But as yet no careful comparison has been made of the efficiency of the beet industry with that of the tropical cane industry. The relative efficiency of the two industries is usually estimated on the basis of yield per acre. Such a comparison makes the beet industry appear inefficient, since the average yield of beets is only 13 tons, or 3987 pounds of sugar, per acre. Cuba produces an average of 17 tons of cane, or 4,155 pounds of raw sugar, per acre. The efficiency of the two industries should not be compared solely on the basis of yield per acre, but on the basis of yield of sugar per unit of labor and of the standard of living of the laborers employed. The United States Department of Agriculture has found that an average acre of beets requires 92 man-hours of labor expended on the farm, whereas an average acre of sugar cane in Louisiana requires 234 man-hours. There are no comparable figures for tropical production of sugar cane; but if one makes the overly optimistic assumption that tropical cane requires only one-half the labor needed in the cane fields of Louisiana, one arrives at a figure of 117 man-hours. On this basis, the average sugar-beet field returns 43.3 pounds of sugar per man-hour of labor expended on the farm, while Cuban sugar-cane returns only 35.3 pounds per man-hour. In the United States, less than eight man-hours of labor are required to produce, refine, and distribute one hundred pounds of sugar.

It is obvious, therefore, that the lower cost of tropical cane sugar is largely the result of differences in standards of living, and not the result of advantages in production or manufacture. The higher production cost of beet sugar merely reflects the higher American standard of living. Moreover, the cost of producing beet and cane sugar should not be compared without considering the secondary benefits derived from the industry. Actually, sugar-beet culture extends benefits far beyond the production of sugar alone. The indirect benefits and advantages show a net gain for beet-sugar production.

The repeated statement that the sugar beet is a "soil-robber" is unwarranted on the basis of actual tests. The crop is soil-depleting, but the amount of plant nutrients taken from the soil is appreciably less than that taken by most crops, such as wheat, corn, or potatoes. In fact, leading agriculturists declare that beet culture actually improves the soil. Beets require a deep and open soil; as a consequence the farmer must plow deeply and carefully. Exacting preparation of the seed-bed and frequent cultivation, required for the best yields, greatly improve the mechanical condition of the soil. Millions of deep fibrous roots, broken off and left to decay after the harvest, add an average of one ton of humus per acre to the soil. Moreover, nearly all of the plant nutrients taken in by the beet can be and usually are returned to the soil. The beet pulp, molasses, and beet tops are fed to live-stock and returned to the fields as manure. Few if any commercial crops can be said to rob the soil less than the beet. Sugar beets have been one of the chief bases for reclamation of land in the West. In an effort to increase beet yields, the farmers have inaugurated extensive and intensive programs of leveling, drainage, and control of alkali.

Beet sugar has supplied an essential need in promoting scientific farming in the West. In many areas where relatively poor agricultural practices were common in the past, where the land was being planted to a single crop or of necessity subject to very limited diversification, beet culture has brought about a significant change. Scientific rotation has followed, with its stabilizing effect on the regional economy. Distinguished agronomists claim that sugar beets are the greatest stimulator of succeeding crops known to agriculture. It is conservatively estimated that when beets are introduced into the cycle of rotation the yield of wheat is increased by fifteen percent, and the yield of other crops common in the irrigated areas of the West by ten percent. An entirely different story must be told of sugar cane, since the cultivation of sugar cane stifles diversification of agriculture and promotes a one-crop economy, with all its social and economic weaknesses.

Sugar-beet production has had a revolutionary effect on the live-stock industry of the West. Traditionally, the western states have been producers of unfinished live-stock "feeders," sent eastward to be fattened for market. Only a part of the profits derived from them was taken by western stockmen. Today, in the best areas, large feeding operations are supported by the by-products of the sugar-beet industry. Beet-tops, beet-pulp, either wet or dry, and residue molasses, when fed with alfalfa and a little grain, will produce finished beef and mutton or lamb more cheaply than any other ration available in the United States. The caloric replacement value of the by-products from an average acre of beets in stock-feeding is equal to two and one-half tons of alfalfa, sixty bushels of barley, or fifty bushels of corn with its accompanying stalks. In addition, the increased feeding incident to the use of these by-products has created a larger, stable local market for hay, grain, and other forage crops. All this enables the farmers to make the largest and most effective use of the neighboring grazing range.

Pen-feeding of large numbers of live-stock makes available large amounts of manure, which is vitally needed in the humus-deficient pedocal soils of the West. Sugar-beet growers are heavy purchasers of fertilizers, since experience has demonstrated the economic value of frequent and heavy applications of manure to beet fields. The value of the fertilizers is not exhausted by a beet crop, but is carried over in the rotation to increase the yields of all the folowing crops. Thus sugar beets, instead of depleting soil fertility, are directly and indirectly responsible for significant improvement of the soil. As a result, land values in regions that produce sugar beets are materially higher than where land is devoted to the more common crops. The benefits to the live-stock industry that arise from the beet industry should be included in any account of the relative cost of producing cane and beet sugar.

Social and Economic Problems

The most vulnerable spot in the defense of the sugar-beet industry lies in its treatment of the large number of laborers formerly needed for production of the beets. It has been dependent on a supply of labor composed of persons in the lowest economic and social stratum. The tactics employed in recruiting foreign-born laborers and the treatment of all beet workers have until very recently been definitely reprehensible. More than ninety thousand workers are normally employed in the fields, the majority of whom are Mexicans or Spanish-Americans; most of the remainder are Filipinos, Russians, and Germans. However, there is a much larger body of these people of low economic status who no longer work in the beet fields, but who remain in the areas of beet production.

These people, whether working in the fields or not, create a serious economic and social problem. The annual income of the average beet family rarely exceeds six hundred dollars, of which approximately three fourths comes from their work in the beet

fields. With an average of 6.4 persons per family, it is obvious that their annual income is far below the minimum required for the support of life, to say nothing of the so-called American standard. The workers make little effort to obtain off-season employment on railways or in other industries, although it must be admitted that there are many barriers to such employment. Instead, the average beet family relies on the charitable institutions of the community or of the state, or on unemployment compensation. The contribution of charity to the total support of these people ranges from thirty-five to ninety-seven percent in different areas.

Social ostracism and segregation of the beet worker has reached proportions equal to that suffered by the Negro in the South. The result is significantlly evident in the low standards of living, child labor, health deficiencies, and lack of education of the beet workers. It is also apparent, though not subject to proof, in the amount of delinquency and crime in these groups. The situation has improved greatly, but is still open to criticism. Actually, so far as hourly wages are concerned, the beet worker is considered an aristocrat by his fellow nationals. The question is not one of the hourly wage scale, but of total annual income.

Regardless of the reason for these problems, it is a fact that the beet workers impose a serious financial drain on the wealth of the sugar-producing states. It is impossible to determine what percentage of the cost of charitable and penal institutions results from the presence of the beet workers. But the direct cost to taxpayers is evidently large, and should be charged against the industry in any analysis of its economic soundness. It should not be considered, however, that all aspects of beet-field labor are bad. A great many immigrant workers, German, Russian, Japanese, and Mexican, through hard work, frugality, and thrift have become respected members of their agricultural communities.

The Future. Recommendations

In recent years several scientific improvements have been made that may revolutionize labor and cost in the industry, through the elimination of most of the stoop-labor. Various machines have been devised, which block out and thin the rows of beet plants very satisfactorily. Experiments show that these machines reduce the human labor from twenty-five to two and one-half hours per acre for such work. Several mechanical harvesters recently devised have proved satisfactory. Tests show that the harvesters will not only eliminate nearly 30 hours of human labor per acre, but will also perform the work almost as satisfactorily as hand labor.

Another technical advance is the use of segmented seeds. The so-called sugar-beet "seed" is not a true seed, but a seed ball, which contains from two to six seeds enclosed in the dried flower parts. When planted, each ball produces a cluster of seedlings. For the best crop, only one plant from each seed ball must be left, the others being removed by arduous hand thinning. Segmented seeds are produced by subjecting the seed balls to a grinding process, which breaks them up into individual seeds, each of which will produce only one plant. This procedure will not only eliminate much hand labor, but will also make it unnecessary, in part, to use the blocking and thinning machines just mentioned. Universal use of these and other improvements in beet culture gives great promise of lowering the production costs of beet sugar to a level where it can compete with cane sugar without recourse to federal tariffs, subsidies, or production allotments.

However, the adoption of the new techniques is progressing very slowly. Perhaps a reduction of federal protection and subsidies to the industry would hasten the adoption of the new techniques and machinery. By adopting them, the industry would place itself on a sounder and more scientific basis, and most of its objectionable aspects would be eliminated. But until federal protection of other agricultural industries is abolished, there appears no logical reason for denying it to the beet-sugar industry.

DUNDEE: A SCOTTISH CITY STUDY*

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Dundee is an old Royal Burgh of Scotland, which ultimately played its part in the rapid development of industrial life in the nineteenth and twentieth centuries. Like most British cities with a similar history, it presents, therefore, the marked contrast between the compact settlement of pre-nineteenth-century days and the constant expansion of city limits and buildings in the more recent phase. The contrast can be seen in the map showing the city's growth, Figure 1. In terms of initial growth, therefore, site values concern the old settlement alone, and the larger area within the present city limits is a part of the immediate environment. For this reason, the term "Dundee region" will be used here for the area which has, up to the present, been incorporated within the contemporary city limits, and will not be used in the general sense of wider regional associations. This distinction can be seen in the geologic and topographic maps, Figures 2 and 3; and apart from its importance in the assessment of the early city, it carries a further significance in the fact that the spread of the city organization over the expanded industrial area of the nineteenth century and later brings with it a social-economic integration that gives the city a specific regional character. The growth of the city region has been largely the product of its possible relationships with other areas, both near and far, and in the final analysis it represents a concentration, or segregation, within a world economic and social fabric.

Site and Region

The potential human significance of the large estuaries of the Tay and the Forth in relation to the regular east coast of Scotland and to the Midland Valley is clear even from an atlas map. The use of such potentialities is shown by the emergence, on the south bank of the Forth, of Edinburgh and Leith, and of Stirling as the bridge point; on the Tay, Dundee and Perth represent essentially the same pattern. It is not surprising, therefore, that during medieval times, when trade with Europe favored an east-coast site, Dundee rose to be the second city of Scotland. The Tay estuary (Fig. 4) narrows toward its mouth, where river and tidal current have had to cut through a band of basalt and andesite, giving rise to the headlands of Broughty Ferry on the north and Tayport on the south. Seaward from these narrows are the sand dune areas, partly developed on the 25-foot raised beach of Barry Links to the north and Tents Muir on the south. These culminate in sandspits, Gaa Spit and Abertay Spit respectively. These spits, while they offer difficulties to navigation, provided a further line of protection to the anchorages of the Tay. The natural channel of the Tay is near the south shore; the north shore is an area of deposition. This fact, as will be seen, made the possible silting-up of the harbor a constant menace.

The geologic and topographic features of the region are shown in Figures 2 and 3 [1]. Essentially it is a quite typical segment of the Midland Valley of Scotland. The main elements in its solid geology are the Old Red Sandstone and intrusive igneous rocks of lower Old Red Sandstone age. To the east, there is a considerable extent of contemporary lavas. The highest lands are in the west, where heights between 500 and 600 feet are reached in Dundee Law and in the northwest of the city. Some of the higher ground is correlated with exposures of the igneous intrusive rocks, as in the ridge that culminates in Balgay Hill and the Law. Drainage is principally toward the southeast. The other element in the physical environment is the cover of glacial deposits. The Law is covered with glacial drift almost to the top of its northwestern face [2], and the whole physical landscape has glacial characteristics.

* Limitations of space have made necessary a drastic abridgment of Mr. Jones's original manuscript.—Ed.

The outline of the old city is shown in both Figures 2 and 3. There is a considerable degree of correlation with an area of diabase intrusion. This intrusion forms the last patch of firm coastland, being succeeded to the west by the sediments of the Carse of Gowrie, which stretch right to the bridge point at Perth. Rising to a height of some 90 feet, it provided a site for town and castle, while its indented southern side gave the basis for the first harbor. The present river frontage is built-up land; the original coast line is shown on the maps. The old wells of the city are shown on the geologic map. Their general relation to the junction of the diabase and the Old Red Sandstone should be noted; the main exception, Ladywell, outside the city limits, gave rise to some friction in certain phases of Dundee's growth.

The site of the old city lies astride the mouth of the Scouring Burn, with the Dens Burn just beyond its eastern limit. Both streams subsequently played an important part in the story of industry, early mills tending to grow up along their courses rather than in any clearly defined industrial zone. Dighty Water was not included in the city limits until 1939, although the city long had mill rights on it. Nevertheless, the presence of a major source of water for power and other industrial uses was also a disturbing element at times when the city was anxious to preserve its industrial prerogatives.

To the west of Dundee (Fig. 4) lies the fertile Carse of Gowrie. Northward, the apparent barrier of the Sidlaws is modified by negotiable gaps leading to Strathmore, important not only for its agricultural products but also for the commercial contacts with the Highlands provided by such towns as Forfar and Kirriemuir. To the south, the Tay is a barrier to communication by land. Ferry service was developed early. Bridge communication, limited to use by the railway, did not come until 1878. Isolation from the more progressive south has, therefore, its place in the story of Dundee. The physical elements noted represent the range of possibilities offered to the community; the study of the development of the city is essentially an analysis of the choices made from the chances offered.

Origin of Dundee

In 1325, King Robert the Bruce commissioned the Abbot of Aberbrothock (Arbroath) and others to enquire into, and report on, the ancient Burghal rights and liberties of Dundee [3]. Following this investigation King Robert, in 1327, issued the charter that confirms "to the burgesses of our burgh of Dundee . . . all liberties and rights which, in the time of . . . William, King of Scots, they held and possessed . . ." [4]. This evidence takes the town's history back possibly to the later twelfth century, William the Lion having reigned from 1165 to 1214. Earlier evidence is scanty. One version of the Anglo-Saxon Chronicle refers to Dundee in 1055 [5], and mention of Dundee in 1064 has been recorded [6]. No clear evidence that takes its origin back to an earlier date has yet come to light.

This study therefore involves a time-span from the middle of the eleventh century to the present. Within so long a period geographic aspects of the problem have varied considerably; and while the flow of events has been essentially uninterrupted, it may be possible to suggest a subdivision in accord with the variation. The simple subdivision suggested, largely for convenience, is: Period I, from the origin of the settlement to the middle of the seventeenth century; Period II, from the middle of the seventeenth century to the present.

Such a division is not purely arbitrary. The first period is one of European trade, in which Dundee achieved considerable prosperity. The second reflects changed circumstances, produced by the development of Atlantic trade, which favored west-coast towns such as Glasgow. In Scotland, the change was further strengthened by the part

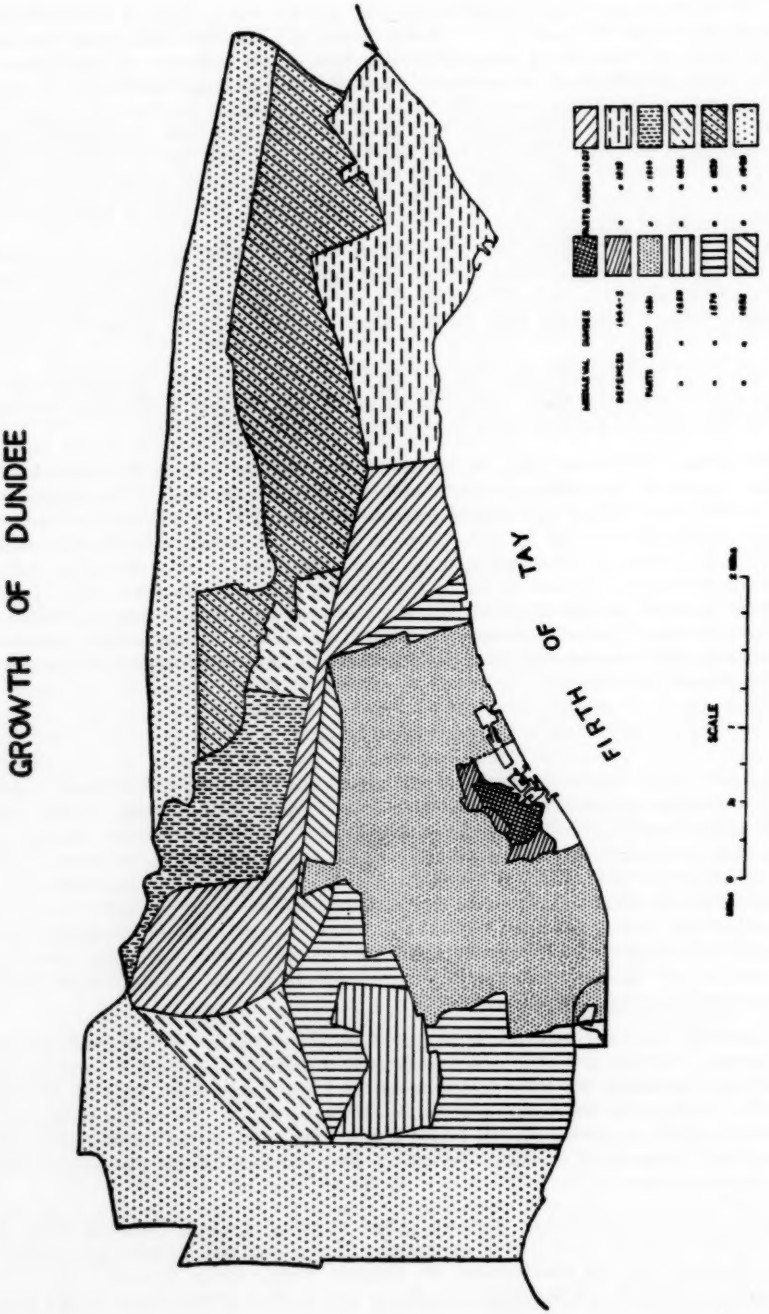

Fig. 1. Expansion of incorporated area, Dundee, from the Middle Ages to the present.

subsequently played by the Lanarkshire coalfield in the industrial history of the early modern phase. In this period, the story of Dundee recounts the overcoming of disadvantages and the slow development of a new basis of prosperity. Choice of the middle of the seventeenth century as a point of division is also influenced by the sacking of the town by General Monk in 1651, a disaster that merely precipitated a challenge that slower economic causes would inevitably have soon brought to the city. In the discussion of the two periods, the economic basis of the life of the city and its morphology will be considered separately.

Period I

Economic basis. The early development of trade is linked with the establishment of a significant position in relation to neighboring areas. In this respect, the previously mentioned charter of Robert the Bruce is important, because of the privileged position it gave Dundee in relation to its immediate hinterland. The charter forbade anyone within the sheriffdom of Forfar except burgesses of Dundee to buy up wool or skins; and further forbade any foreign merchant coming within the sheriffdom and burgh to trade with any except the burgesses of Dundee, the rights of other burghs within the sheriffdom being reserved. It forbade foreign merchants to dispose of goods brought by land or sea until they had first landed and exposed them for sale in Dundee [7]. Assurance of these privileges in relation to a hinterland obviously favored Dundee's early development; it also illustrates the interplay of human and physical elements that frequently enters into problems of this kind. The struggle for supremacy in the Tay estuary still left, however, the relative positions of the estuary town, Dundee, and the bridge-point town, Perth, undecided (Fig. 4). There is documentary evidence of this struggle. Early rivalry "as to the privileges of the Water of Tay" was resolved in 1404 in favor of Dundee [8]. In practice this award was not so decisive as it appears to be; and the dispute, rarely dormant, flared up in the late sixteenth and early seventeenth centuries. As late as 1600, Perth secured a charter from James VI of Scotland (later James I of England), which recognized all the claims so long put forth by Perth to the exclusive rights of shipping in the Tay. Dundee's reaction was immediate, and a new attempt at a solution was made in 1602, when a decree of the Court of Session limited the privilege of Perth to have free ports on the Tay to that part of the river along the County of Perth, and awarded a similar privilege to Dundee on the river opposite Forfarshire, not only on the north but also on the south side of the Tay. The rights thus defined were confirmed in 1642 by the charter of Charles I [9]. By the end of the first period, therefore, Dundee was establishing itself firmly, and later developments further strengthened the position of the estuary port. Apart from the rivalry with Perth, the award of the banks of the lower Tay to Dundee strengthened the town in so far as these rights forbade the rise of a coastal rival.

The prize to be gained by this consolidation of local power with reference to the Tay estuary and its bordering lands was full participation in the maritime commerce of western Europe. Within the wide net of this commerce, the centers of concentrated commercial activity were Flanders and the Baltic. Initially, Flanders was the more important, and retained outsanding significance until the middle of the sixteenth century. This was the natural market for Scottish raw materials and for the purchase of finished goods. Trade was originally centered in Bruges, but because of political difficulties it shifted toward the estuary of the lower Scheldt. From competition during the fifteenth and sixteenth centuries, Campveere (now Veere on Walcheren) emerged in 1541 as the sole staple for Scottish trade [10].

The Baltic appeared early as a source of timber and iron, but as a supplier of raw materials could not achieve the same trade balance as Flanders. Baltic trade became increasingly important with time, a fact that may be linked with the growth of manufactures in Dundee. The first record of importation of timber dates from 1331, but

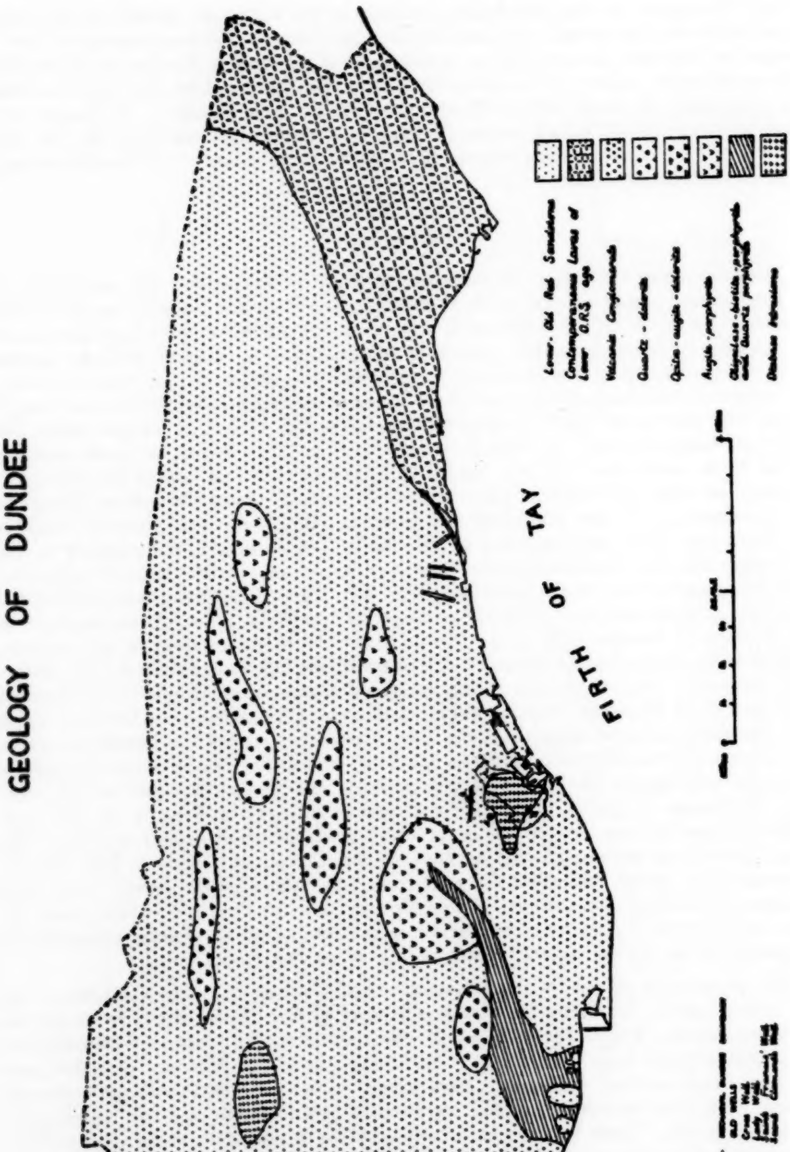

Fig. 2. Geology of Dundee.

the source of the timber is not given. At the end of this period, the account books of David Wedderburne, a Dundee merchant, show considerable contacts with the Baltic in the late sixteenth and early seventeenth centuries [11].

Export of raw materials is the most prominent feature of Dundee's early trade, but the early emergence of industry and its effects on commerce are ultimately involved. Traditionally Dundee has nine incorporated trades: Bakers, Shoemakers, Glovers, Tailors, Bonnetmakers, Fleshers, Hammermen, Weavers and Dyers. Warden [12], the principal student of these trades, finds no reason to doubt that many if not all of them existed in the fourteenth century or perhaps earlier; and that some of them had Deacons by about the middle of the fifteenth century if not earlier. The oldest charter in the possession of the Weaver Trade was granted in 1475, but does not refer specifically to the Trade itself. A more positive reference to the Weaver Craft occurs in 1497. The first customs exacted for the export of woollen cloth are noted in the year 1437, while by 1479 no less than 205 score and 6 dozen ells of woollen cloth were exported from Dundee [13]. It would therefore seem that Dundee's function as an exporter of raw materials is increasingly modified from the fifteenth century onward. This development of textiles is important for a full appreciation of Dundee's recovery in Period II. It should be noted, however, that in the period of 1480-1487 the customs on wool and hides in Scotland totaled 2,600 pounds, whereas those on woollen cloth brought in only 108 pounds. For the latter, the principal export points were Leith (customs 50 pounds), Kirkcudbright (customs 16 pounds), and Dundee (customs 9 pounds) [14].

It is not necessary to mention more than the main commodities included in Dundee's commerce. Until the middle of the fifteenth century, the export trade rested primarily on wool, sheepskins, and hides. Imports included super-tunics of gray cloth and of colored materials, several pieces of dyed fabrics for the King's use, and confections and pepper imported for the royal household. Dundee owed a good deal to the development of its hinterland by the Church: for example, by the monastery of Coupar Angus and the Abbey of Arbroath (Aberbrothock) with its scattered holdings through Strathmore. The household of the royal palace at Forfar stimulated some imports.

The account books of David Wedderburne, which cover the period 1587-1630, and the contemporary Shipping Lists of Dundee give a comprehensive picture of trade in the latter part of the first period [15]. Woollen cloth (plaiding) and some linen now figure clearly in the exports; the regional contacts are the same as have previously been defined. The range of imports was wide, although quantities of many commodities were small. The accounts include marmalade from Spain; confectionery, Canary sugar, syrup, and aniseed oil from Flanders; olive oil and wine from France and Spain; and even "tubacco" from the West Indies by way of France. Wine came in sufficient quantities to suggest that Dundee was one of the main ports for the distribution of wine in Scotland. Salt came from La Rochelle and St. Martins in France, dyestuffs from Dieppe and Bordeaux. The Baltic trade provided timber in various forms, pitch, tar, hemp, ropes, iron, iron nails, lead, copper kettles, rye, wax and glass. It would seem that Dundee had between twenty and thirty ships trading with the Baltic. In addition to the overseas commerce, coastal trade with other parts of Scotland was important.

In competition with the other commercial towns in Scotland, Dundee had by the end of the sixteenth century attained second place, surpassed only by Edinburgh, having outdistanced its old rivals, Perth and Aberdeen [16].

Morphology. Dundee's main original component elements, castle and church, can not as yet be given equal age. The significance of the castle is difficult to assess. The first definite reference to it is in 1292 [17], and it is not mentioned after the battle of Bannockburn, 1314. Knowledge of it is therefore limited to 22 years. The castle is probably older than the first reference to it, and its presence in the early thirteenth century may be implied by contemporary references to a Castle Wynd (Way or Lane) [18]. On the basis of factual knowledge, however, the town must be assigned a greater age than the castle, so that Dundee is not a "castle town" by origin and nature. An important fact is that the office of Constable lived on after the castle disappeared; the consequence of this fact will be noted later. The disappearance of Dundee Castle ultimately

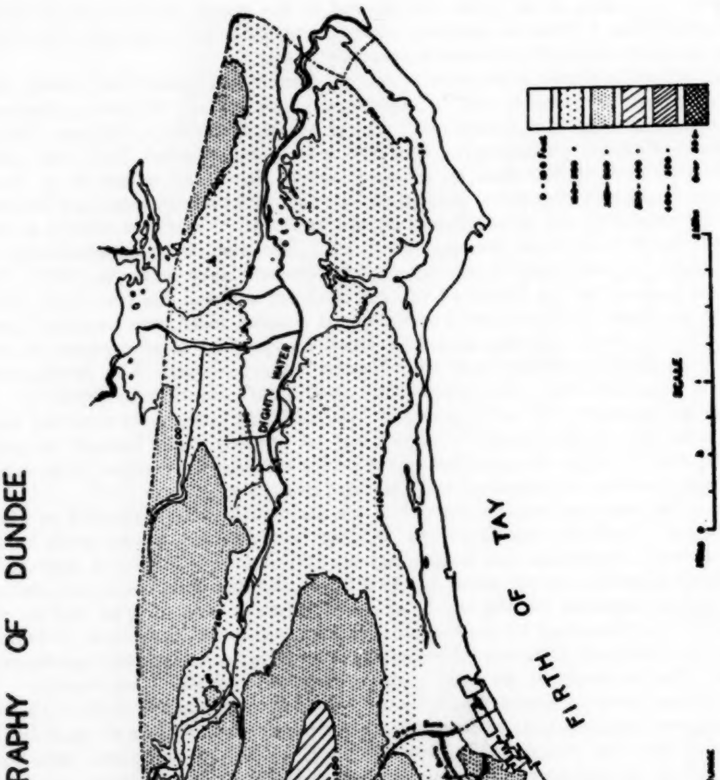

Fig. 3. Topography of Dundee.

gave importance to Broughty Castle, built on a headland to guard the narrow mouth of the Tay estuary, which became important with the increase of sea warfare from the sixteenth century onward. The church of St. Mary was founded toward the end of the twelfth century, and is therefore also younger than the town [19]. It was under the care of the Abbey of Lindores, in Fife, until it was transferred to the town in 1442 [20]. Thus the church was not a feature of the earliest town pattern. The period of building walls and ditches extends from 1592 to 1646. Church, castle, and walls are therefore additions to the original town.

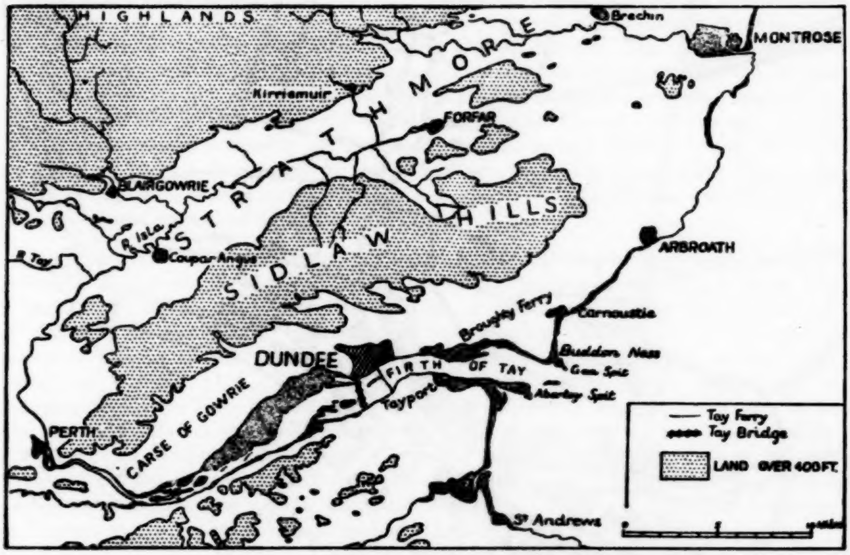

Fig. 4. The Regional Setting of Dundee.

For a discussion of the street pattern within the town limits, it is best to start with evidence from Period II and examine its validity for Period I. Crawford's map (Fig. 5) is the best beginning. The pattern of the central part of the town is a familiar one. The broad High Street is prominent, and its relation to the sites of church and castle should be noted. On the east, Murraygait and Seagait lead into it; on the west, Overgait and Nethergait. Toward the Tay, narrow streets, of which Tindal's Wynd is particularly significant, feed it from the harbor. It is more difficult to trace the development of the pattern than to note its state in 1776. Dr. Small, writing in 1792, states that Old Dundee seems to have consisted of two parallel streets, the Seagate and Cowgate. He adds that the present "centre" is not the original one, and that St. Mary's church was once "the Kirk in the field" [21]. Lamb notes that the first Cross of Dundee was in Seagate, but the date of its removal is unknown, although a reference of 1442 would seem to place it in its later position near the church. The erection of the Tron in High Street in 1364 and the removal of the Tolbooth to High Street about 1440 are undoubtedly part of the same story [22]. Following heavy damage by English intruders in 1385, the church remained in disrepair until the town agitated for its transfer to the town authorities. The transfer was effected in 1442, a date that coincides significantly with other changes noted [23]. It would seem that the middle of the fifteenth century saw considerable integration of what was to be the pattern of the heart of the town. The commercial growth of the town probably provided a direct stimulus, as it has been justly pointed out that access to the harbor is easier from High Street than from the old center, Seagate, which lies to the east of Castle Rock [24].

Apart from the street plan of the central parts of the town, Crawford's map shows some ribbon development along the main roads. One aspect of the growth beyond the

old city limits deserves special attention, and is an intteresting addition to our knowledge of early "suburbs." It concerns the district of Hilltown (Fig. 5). The fortalice of Dudhope Castle became the home of Scrymgeour family; it is thought to have been in existence in 1298, but was replaced about 1460 by a more extensive and better fortified residence, and has been considerably modified in later times [25]. It has already been noted that the office and privileges of the Constable survived the destruction of

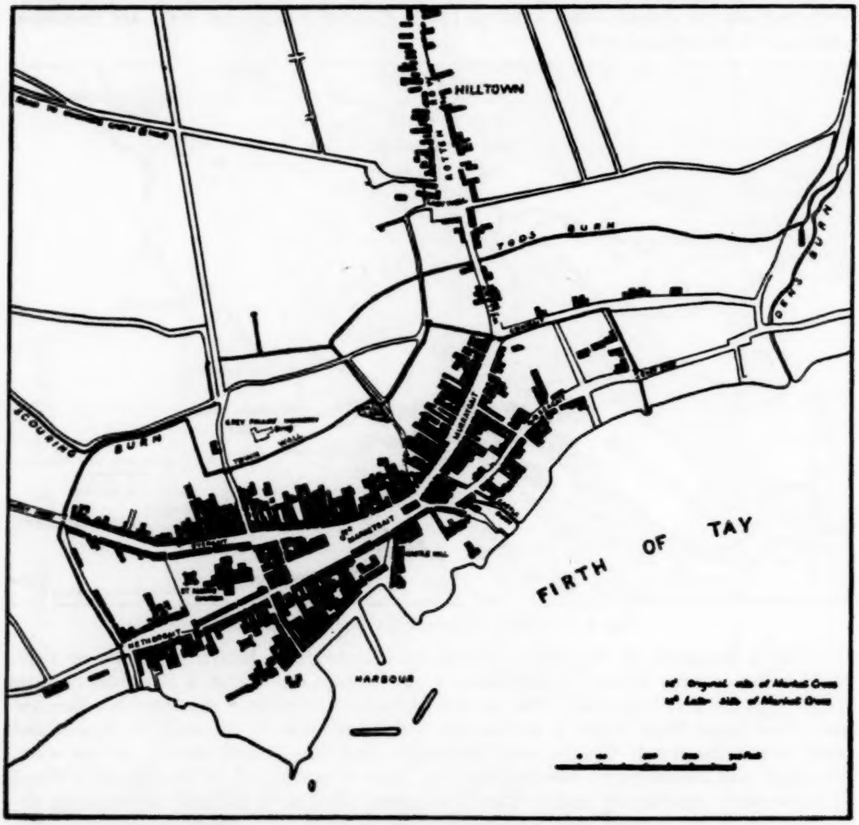

Fig. 5 Dundee according to Crawford's map.

Dundee Castle: in this survival lay the friction between fortalice and town, which culminated in the later part of Period I. In 1590 a Charter of Barony was granted to Sir James Scrymgeour [26], while in 1643 Hilltown was created into a Burgh of Barony [27]. Hilltown was a ribbon development of houses on the Scrymgeour estate immediately north of the town. The burghers of Dundee could not tolerate for long the presence of an independent unit, the inhabitants of which could scorn the commercial and industrial regulations of their city. Within a few weeks Dundee concluded an agreement with the Viscount of Dudhope by which it gained some control over industrial development outside its walls. Finally Hilltown was sold to Dundee, the sale being the occasion of a new charter in favor of Dundee in 1697 [28]. Subsequently Dundee, in turn, sold land to Hilltown, but was careful to preserve its rights so that no new industrial competition might arise [29]. From the late seventeenth century, therefore, the district has been under the control of Dundee, although the privileges of the Constable were not entirely abolished until 1745 [30].

Period II

The first half of the seventeenth century brings to a close Dundee's initial period of prosperity, and heralds a time of choice among the possibilities offered by a changing geographic pattern that blends old circumstances with new. The immediate, abrupt cause of decline was the sack of the city by Monk in 1651, an incident arising from the repercussions of the Civil War in England. This incident, however, merely precipitated what, under normal geographic circumstances, would have been a testing time. The growth of transatlantic commerce with the new colonies of North America was to favor west-coast ports. Glasgow arises when Dundee declines. The industrial development that accompanied extended commerce was, during the eighteenth century, to take root in the Lanarkshire coalfield and further strengthen Glasgow's growth. The evaluation of these new circumstances and the choices that led Dundee not only to recovery but also to renewed prosperity are the themes of this second period. But at the time of Dundee's decline the growth of towns had not reached a point where there were many strong rivals to take its place. Thus in a tax list of 1695 Dundee was still fourth, Glasgow appearing second to Edinburgh [31].

The second half of the seventeenth and the early eighteenth century see the initial attempts to correct the damage to Dundee, and something most be said about this critical period before continuing the discussion of the economic basis and morphology of the city. Of considerable interest is the report on the "State and Condition of the Town of Dundee in 1692" contained in the records of the Convention of the Royal Burghs of Scotland [32]. The skeleton of the town's earlier prosperity can still be recognized. Fifteen ships and six barques are listed as owned by local merchants, while the links with the fertile lands of Strathmore and the Carse of Gowrie are shown by the appearance of Glamis, Kirriemuir, Alyth, Coupar Angus, Miglie and Newtyle, and Errol as "burghs of barronie and regality to the burgh of Dundee." The state of the harbor seems to have been a major obstacle to recovery. The encouragement of craftsmen to fill gaps in the town's economic structure was necessary to rehabilitation.

There is abundant evidence that Dundee was still struggling to repair its damage throughout the first quarter of the eighteenth century. That it should not only achieve considerable recovery during the remainder of the century but also lay the basis of a renewed prosperity can only be understood by looking briefly at the broader picture of economic development in eighteenth-century Scotland. The further political and economic integration of the British Isles achieved by the Union of England and Scotland in 1707 obviously led to far-reaching changes, of which two are pertinent here. The Union tended to encourage the English and discourage the Scottish woollen industry. In compensation, the Scottish linen industry was singled out as a major means of bringing industrial prosperity to the north. Morever, colonial markets were opened to Scotland, creating what has been described as a "prodigious vent" for linens and other goods. This ultimately more than compensated for the privileges Scotland enjoyed in Dutch and French markets in the days of antagonism with England. Following the Union, several specific efforts to encourage industry were made, which culminated in the institution of the Board of Trustees for Manufactures as part of the Stamp Act legislation of 1727. The creation of a Linen Bounty on exported linens is also significant. This bounty was approved in 1742, and continued, with modifications and some interruptions, until it finally ceased in 1832.

The rebellion of 1745 led to further efforts to promote industrial growth in Scotland. In 1746 the British Linen Company was inaugurated at Edinburgh, with a capital of £100,000 sterling. One of the chief objects of the company was to supply British merchants trading to Africa and the British Plantations with such kinds of linen cloth as they had previously been obliged to purchase from foreign nations. The

company became the buyer and distributor of necessary raw materials, and the buyer of finished linen that found its way to company warehouses to await export. Special attention was paid to coarse linens suitable for the American plantations and the West Indies. Finally, it was realized that the Company could function most efficiently as a supplier of capital to those directly engaged in the industry, and consequently it tended increasingly to adopt banking as its sole business.

The Stamp Act of 1727 had some important repercussions. Its main purpose was to initiate supervision in the hope of achieving some uniformity in the "domestic" phase. To some extent, the operation of the act was selective in the industrial field. Sailcloth was exempted from the operation of the act, although, until 1820, manufacturers had to stamp their names on their cloth. Until 1814, cotton bagging was also exempt. The long controversies associated with the act need not be noted; objections to it led ultimately to its repeal in 1821.

This general background established, Dundee's efforts "to emerge out of the gloom" can be studied in more detail, and the form of argument adopted in the discussion of the first period can be resumed.

Economic Basis. Early clues to Dundee's new line of progress are contained in the Minutes and Annual Reports of the Board of Trustees for Manufactures. The condition of the town is reflected by the record in 1729 that Dundee refused the offer of a spinning-school because it had no funds to devote to this purpose. Enterprise in keeping with the times was nevertheless not lacking. In 1732 the Dean of Guild, Dundee, sent to the Board samples of coarse cloth, whitened with kelp because this was cheaper than other bleaching materials. The Trustees announced their proposal to erect bleaching fields using this process at Dundee and Dunfermline, and the inventor of the process, Richard Holden, set up a bleachfield for the purpose at Pitkerro, near Dundee. An important decision was made in 1740, when the Trustees ordered "several trials to be made for obtaining the skill of spinning that slack and gross kind of yarn that is fit for Osnaburgs and other coarse Linens used in the American Plantations, and directed sundry experiments to be made of making these kinds of goods from yarn spun in this country." By 1742 the production of small quantities of such material, particularly at Dundee and Arbroath, could be reported. By 1747 the fabric of the cloth was much improved and the quantity made greatly increased; improvement was attributed to "the bounty lately granted on the exportation of coarse Linen, and to a great spirit for manufacture promoted over the country by means of the British Linen Company" [33].

Bounty rates were applied according to the value of the goods per yard. The manufacturers of Forfarshire, by setting the price of their coarse product at the lowest limit of the price class for which the highest bounty was paid (*6d* to 1*s*/*6d* per yard), were able to obtain a bounty as large as that paid to the makers of a finer product [34]. It was the careful cultivation of this opportunity for the profitable manufacture of coarse linens, occasioned by the bounty and the opening of new markets, that underlies Dundee's recovery. The choice was still more fortunate in that it utilized the tradition of spinning and weaving long current in the town and its hinterland without up-grading standards. Of the raw materials, flax was a product of local agriculture, and both flax and hemp could be readily obtained through Dundee's traditional trade links with Baltic ports. In some ways, therefore, Dundee's recovery rested on the revival of an old pattern at a time when the shift of commerce and industry to the west coast seemed at first glance to create almost insuperable difficulties.

There is some indication of changes in the customs accounts for 1745 [35], but this date is a little early for the new pattern to be fully developed. In industry, the "Linnen manufactory" is most conspicuous, together with yard-wide shirting, Osna-

burgs, duck or sailcloth, and white and colored thread. The local spinning industry could make anything "from a cable to a single cord." A large trade in grain was reported. The harbor is said to be capable of holding 200 vessels and of receiving vessels of up to 300 tons burden. Seventy ships were owned in the town. Mention of a vessel belonging to the "Whale fishing Company" is of interest because Dundee's participation in the whale industry was later to help the introduction of jute.

Small's "Statistical Account" of 1792 gathers together the threads of the development of the town in the eighteenth century and provides a view of it before another important phase of change. Small notes that as devastating as the sack of the town by Monk was the effect of the Union of 1707 on the plaiding industry, the spinning and weaving of coarse woollens for the Dutch market, where they were thickened and dyed for the clothing of troops in various parts of Germany. The principal and staple manufacture in Dundee was now linen, the main products being Osnaburgs and other similiar coarse fabrics of different names, canvas for shipping, sackcloth mainly for the supply of the local countryside, bagging for cotton wool, diaper (only one firm), and household linen. The colored-thread industry remained important, but an interesting comment is that the spinners of the thread lived "in distant parts of Scotland, where labour is cheaper than in Dundee." Small also notes the recent introduction of the cotton industry. This appearance of cotton in eastern Scotland is of considerable interest. It gains in significance in view of the fact that it precedes the introduction of jute, which was destined to become a great rival of coarse cotton goods. Minor industries included wool, yarn for muslin, tanning, cordage, glass, sugar, tobacco, and snuff [36].

The harbor continued to offer difficulties. Despite some improvements the problem of keeping it clear of silt remained serious. A notice of the excellent road for ships between the harbor and Broughty Castle is a forerunner of the use of this advantage in the harbor extensions of the nineteenth century.

Either in 1792 or in 1793 the first small flax-spinning mill to be driven by a steam engine was built in the town. Henceforth new aspects of industrial growth have to be considered. Briefly, these center around the construction of steam-driven mills and the consequent increase in machinery, the relation of such developments to the "coarse" linen trade of Dundee, and finally the emergence of the new material, jute, with which the town's name is inevitably linked. From these strands is woven the essential industrial pattern of the nineteenth and twentieth centuries.

Perhaps the true turning point in the growth of steam-power in Dundee was the erection of a large spinning-mill in 1806 [37]. The question of using cotton in this mill was mooted, but flax was finally chosen. The first power-driven calendar and press came in 1822, but the first power-loom factory was opened in 1836. From the latter date, some degree of balance between spinning and weaving was possible, and the new power-basis of industry can be said to be achieved. New and old methods continued side by side, however, some hand looms still being worked in 1864. In 1816 the possible handicap of relatively scanty supplies of industrial water was noted. It would seem that early development was based largely on the Scouring Burn and the Dens Burn, although more research on this problem is needed [38].

The development of power-driven machinery raised the associated problem of designing such machinery to suit the "coarse" trade of the town, or, alternatively, to find ways of preparing fibers to render them usable in the new mills. A most significant step in the latter approach to the problem was the success achieved in the spinning of tow, the waste product obtained when flax was dressed. The perfection of tow-spinning was the beginning of the tendency toward the utilization of cheaper fibers, a tendency first noticeable in 1816, when Sunn hemp from India was added to the list of raw materials. It is from this background that jute emerges.

The East India Company imported small quantities of jute as early as 1796 or 1797, interest in it being based on its traditional use in the native textile industry of Bengal. Subsequent experiments with it in Britain are associated with the towns of Abingdon (Oxfordshire) and Dundee. The first critical date in Dundee is 1832, when some jute was spun by a firm that continued to spin small quantities. The association with the year 1832 is particularly significant because this year also saw the end of the linen bounties. Thus linen was exposed to full competition within the textile industry; competition that was bound to arouse interest in a cheap fiber such as jute. The next major event in the establishment of jute was the agreement by the Dutch government in 1838 to the substitution of jute yarn for flax tow yarns in the manufacture of coffee-bagging for their East Indian possessions. This agreement may be said to have given a proper start to the jute trade in Dundee, and to have given an impulse to the spinning of jute that was never subsequently lost.

From this time onward, the main features in the development of jute can be most succinctly expressed in terms of its relations to flax and hemp within the linen industry, and to cotton within the broader field of general textile progress in Britain. The growing of flax in Scotland had not, despite subsidies, kept pace with the development of the linen industry. On the contrary, it had declined, and the main supplies of both flax and hemp came from Russia, Prussia, Holland, and Brabant. In 1838, the year in which agreement was reached with the Dutch government concerning jute bagging, there was a strong possibility of war between Russia and Britain. Political tension and uncertain harvests led to great fluctuations in the price and supplies of flax and hemp, this handicap to the linen industry culminating when war with Russia eventually came in the Crimea. That jute prospered under such circumstances is readily understandable. In 1855, jute imports into Dundee exceeded flax imports. In 1858, jute imports exceeded the combined imports of flax, flax codilla, hemp, and hemp codilla [39].

This rapid growth of jute to a dominant position within the structure of the local linen industry owes a good deal to broader issues within the textile industry. The uncertainty of flax prices rendered precarious the position of the linen industry when the bounties were stopped in 1832, the main threat coming from the expanding cotton industry. In 1835, the danger of competition by cotton was openly noted in the local press, and deemed to justify to some degree the still unpopular step of using cheaper substitutes in the linen industry. Of such possible substitutes, jute is specifically mentioned [40]. There can be little doubt that jute owed much to this necessity for adjustment. That it triumphed over the challenge of cotton is also to some extent due to political circumstances. The American Civil War temporarily had disastrous effects on the British cotton industry, and gave the jute industry of Dundee an opportunity of which it took full advantage. Thus with two wars affecting its rivals, jute advanced so markedly that an outstanding peak in its initial development was reached by the early 1870's. From then on, it never loses its place as Dundee's major industry.

Jute was brought to Dundee directly from overseas, by coastal shipping from other British ports, and by the Perth railway. In 1863, the following amounts were brought by these three routes, in order: 6,997, 25,276, and 14,710 tons [41]. The dominance of coastal shipping in the sea traffic is conspicuous; a dominance that continued the pattern of transport of the eighteenth century. Pertinent to this was the formation, in 1798, of the Dundee, Perth and London Shipping Company, which was early extended to include trade with Glasgow. The building of steamers for this company apparently dates mainly from 1832, the stimulus being the need to keep up with the rival ports of Leith and Aberdeen [42]. The figure given above for direct imports from abroad marks a great increase over earlier years, and reflects the real beginning of this aspect of the industry. Cargoes of jute direct from Calcutta to Dundee date from 1840, but the amounts were then small. During the early 1860's, when the jute industry flourished

against the background of the American Civil War, money was increasingly turned back into the industry, and some of this was used to improve shipping facilities. At least two Dundee firms took the opportunity of buying clipper ships to bring jute direct from Calcutta. This aspect also links with the development of Dundee's harbor. It had grown steadily from 1815, features of the later growth being the two new docks of 1865 and 1875, and the wharf extensions of the periods 1885-1886, 1890-1891, and more recently up to 1926. The harbor improvements of the latter nineteenth century aided the increase in direct shipments. It has been justifiably said that the considerable development of river wharves at Dundee reflects the concentrated seasonal nature of the jute imports. The railway early became important for imports into the city, making Dundee in this respect dependent on its traditional rival, the bridge-point town of Perth. Coastal trade has never fully compensated for the lack of direct land communication southward; the barrier of the Tay has maintained a degree of isolation that has affected the full industrial growth of Dundee. The first Tay bridge was opened and destroyed in 1878; the second was not opened until 1887. Even then the benefit was limited until the opening of the Forth Bridge in 1890, and road bridges are a contemporary issue.

The details of the jute industry after its establishment as the town's major economic activity will not be considered here. Detectable signs of change are, however, pertinent. Thought favorable to change arises from the very dominance of jute; a dominance that has led to the view that jute made Dundee "a single industry town." Eastham [43] defined the situation closely by reference to the numbers registered in the city under the Unemployment Insurance Acts in July, 1938. Of a total of 72,000, nearly 26,000 were employed in the jute industry. Omitting distributive trades, all other industrial groups numbered less than 3,000, and of these general engineering, which was largely textile engineering, and bleaching and dyeing were mainly dependent on the jute industry. Thus while there is an underlying varied industrial pattern, in which one thinks of engineering, shipbuilding, and marmalade, the outstanding place of jute is clear. The industry has faced the competition of mills in Calcutta, which developed rapidly in the period between 1865 and 1878 and which have affected the market for grain bags. Possible economic repercussions of recent political changes in India are obviously of vital concern to the city. Thus further change within the ancient linen industry may be impending. Linked with the question of change is also the attempt to attract new industries to the city's recently developed trading estates. Here the provision of modern factories and a supply of intelligent labor that quickly learns a new skill are the incentives. Assembly industries figure largely in this new movement, but the development of the trading estates is a topic that requires separate treatment.

Morphology. Dundee shares with most British industrial towns the story of constantly expanding boundaries in the nineteenth and twentieth centuries (Fig. 1). The main features of this expansion can be readily seen by reference to the maps, which illustrate growth and topography, and discussion may be confined to a few comments. Until 1831, Dundee was essentially the area within the circuit of the seventeenth-century walls, although ribbon extension beyond the wall had already started. The extension of 1831 brings the town more into line with contemporary growth. Later additions maintain what is, in the main, a concentric development, but one should note the extension to the east along the shore of the estuary, which brought Broughty Ferry within the city limits in 1913. The boundary changes of 1939 and 1946 deepened this eastward growth landward, and brought an important section of the valley of Dighty Water within the city. Dighty Water, supplying the water for a series of bleach-fields along its valley, had played an important part in the industrial progress of the city, and its relatively late incorporation is of interest. The 1946 boundary is associated with the latest phase of change in the city's life. The new area brought into the northwest

part of the city has seen the major development of trading estates. Linked closely with this has been the construction of an arterial road, the Kingsway, around the northern periphery of the city.. The Law presents difficulties to internal transport in Dundee, and the Kingsway is a first effort to integrate the pattern of road transport.

A detailed analysis of the mechanism of town growth in the nineteenth and twentieth centuries still waits to be done, and is too big a topic to introduce toward the end of this paper. It is clear, however, that it links with industrial growth and involves the incorporation of neighboring areas closely associated with the town's development but not necessarily within the town until after considerable industrial growth has taken place. Lochee, brought in by the extension of 1859, had an independent history before that date. Thus extension also involves the incorporation of smaller, independent units of settlement which, after incorporation, may become the nuclei of suburban growth. What is important for the present purpose is to note that morphologically as well as industrially one is left with a picture of change; change in the past and potential change in the future. Growth and change are as inherent in the situation today as they have been at any time in the past.

The study of Dundee raises broader geographic issues. Its sustained industrial growth has been dependent upon choices made from ever-changing geographic potentialities; choices involving local and distant circumstances. In that sense, it has been an ever-growing economic unit understandable only in terms of its world background. The extensions of its boundaries, on the other hand, have meant the spred of civic authority over this growing economic unit. In other words, Dundee, like most other cities, represents an integration of economic and social factors that creates a recognizable unit; a unit that cannot be divorced from world circumstances, but which has a clear entity. Thus, despite the specific problems involved in such a concentration, city studies clearly have a regional aspect, and this paper may appropriately end by putting its introductory remarks into the form of a question: can town and city studies help in the elucidation of regional problems in a constantly changing world?

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FISHING AMONG PRIMITIVE PEOPLES: A THEME IN CULTURAL GEOGRAPHY

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American geographers have made several good studies of the salt-water fisheries of our day, but they have not done much with fresh-water fishing, and have given hardly any attention to the fishery of native North America.

Fresh-water fishery has been overlooked, perhaps, because of its rather small commercial importance in our present economy. But in primitive times, when most of the American Indians did not have the equipment required for the larger offshore fisheries, rivers and lakes, and the water along the shore, provided most of the fish they captured. It may also be submitted that a theme of inquiry does not necessarily gain significance because big quantities are involved. The archeologist values his pottery, not according to the number of tons of potsherds he can collect, but because pottery is a magic lamp that throws light on his problems of chronology; in the same manner of speaking, quantity of fish as a commodity, while not unimportant, is not the core of the theme proposed here. Rather, the value of studying the fishing of primitive folk lies in the promise that such investigations may throw a modest light on some of the problems of cultural geography.

The curiosity of a cultural geographers is always aroused by questions of relations between different cultural areas; and a study of fishing in those areas may help to clarify such relations. A brief review of some of the results obtained from a study of fishing in native California and the bordering regions will serve as an illustration [1].

There was fishing of a sort even in the arid lands east and southeast of California; but if the Apaches, the Utes, or the southern Paiutes fished at all they used such implements as a simple club, the spear, the bow and arrow, and a very rudimentary trap. The technique of driving fish into shallow waters or into corners was very common. Sexual continence was not required before fishing, but it was before hunting. Hunting, in fact, is the word that characterizes their taking of fish: they employed their customary hunting weapons and methods to take a game that happened to be in the water. They had none of the specialized implements of true fishermen, such as harpoons, fish hooks, fish nets, or weirs. In short, they can hardly be called fishermen at all. As laboratory specimens these fish hunters are interesting, since they seem to exemplify the kind of threshold situation from which fishing may once have originated. It can be postulated that men first hunted land game, then added hunting in the water, and finally developed implements designed for use in water, thus becoming true fishermen. It is not proposed, of course, that the Paiutes or Apaches as such were extremely ancient occupants of their land, nor that they were belatedly on the way to becoming fishermen; it is the unspecialized character of their fishing or fish hunting that is intriguing. It is quite clear that the California Indians learned little if anything about fishing from their neighbors in the arid lands.

North of California the situation was very different from the one just described. The northern neighbors of the California Indians were highly skilled and specialized fishermen: they had several kinds of fish hooks, different types of fish nets with specially made net sinkers and floats, and the sinkers were often quite complex artifacts, grooved, bored, or wrapped stone objects. They also had special implements for gauging the size of mesh in net making, different meshes for different fishes, complex harpoons, elaborately constructed weirs and traps, manufactured clubs to be used only for the killing of fish, the requirement of sexual continence before fishing, socially important fish rituals,

and such ideas as that fishing songs were private property and that one must not speak disrespectfully of the fish.

This fishing complex and the pervasive atmosphere of fish in social institutions and folk lore penetrated into California, but on the whole its complexity diminished with latitude. Distribution maps of the various fishing implements and methods reveal a rather clear southern limit of most of the highly specialized fishing traits.

On the other hand, if the maps be searched for elements that have a northern limit but no southern or eastern one, such items as the following stand out: shooting of fish with bow and arrow, use of fish poison, requirement of sexual continence before hunting but not before fishing, or taboo against eating fish. It need hardly be pointed out that these ideas, with the exception of fish poison, are alien to most fishing cultures.

The conclusion to be drawn is obvious: the strongest influence on California fishing came from the north, while the influence from the east or south was at best very weak. One might go farther, and say that all true fishing in California was merely the southern extension of the Northwest fishing culture. Exception must at present be made for the maritime fishing culture in the Santa Barbara region. In many respects it was unique in California, perhaps even in North America, and its origin seems yet to be determined.

No claim to originality is made for this conclusion, for long ago the anthropologists, basing their arguments on other types of evidence, demonstrated the northern origin of much that was basic in California material culture [2, 3, 4]. But since the present study is an experiment in technique, it is encouraging to find that it produces results that generally agree with those derived from studies that employed other and perhaps better-established methods.

Another anthropogeographic problem is brought to mind by Ratzel's statement that the essence of culture history is movement [5]. Movement is a suggestive word; and it immediately raises questions concerning where, whence, whither, along what routes movement has taken place. These are all good geographic questions, and the task of identifying the route or routes of culture movements is most fittingly assumed by the geographer, for of all people it seems that he should be the one who may be expected to have the tools and techniques for dealing with such questions.

One tool for identifying routes of culture movements is the distribution map, provided that it is made on a scale large enough to fit the problem. If an artifact is so complex that independent invention in several different localities is unlikely, for example a fish club or a harpoon of particular structure, form, or function, then the symbols on the map representing the known presence of that artifact become trail markers of a road once traveled by the artifact or by the men who had the idea of the artifact. The other indispensable tool is of course the topographic map, which shows the lay of the land and possible water routes. The latter are most important in the present study, for it is to be noted that artifacts or ideas associated with fishing normally occur only near water. In other words, fishing methods diffuse by way of fishing waters.

When the distribution map, as cultural trail marker, is projected on the topographic map, it is seen at once that only four possible routes lead from the north into California. The most easterly of these routes extends from the Columbia River southward along the Snake, Owyhee, Humboldt, and Carson Rivers. It can be called the Nevada route for short; and it may be said at once that the cultural evidence is strongly against any significant diffusion of fishing techniques to California by way of this trail. Interestingly enough, however, it looks very much as if the use of fish poison spread northward from California by this very route (Figure 1).

The second possible route from the Columbia by way of the Deschutes and

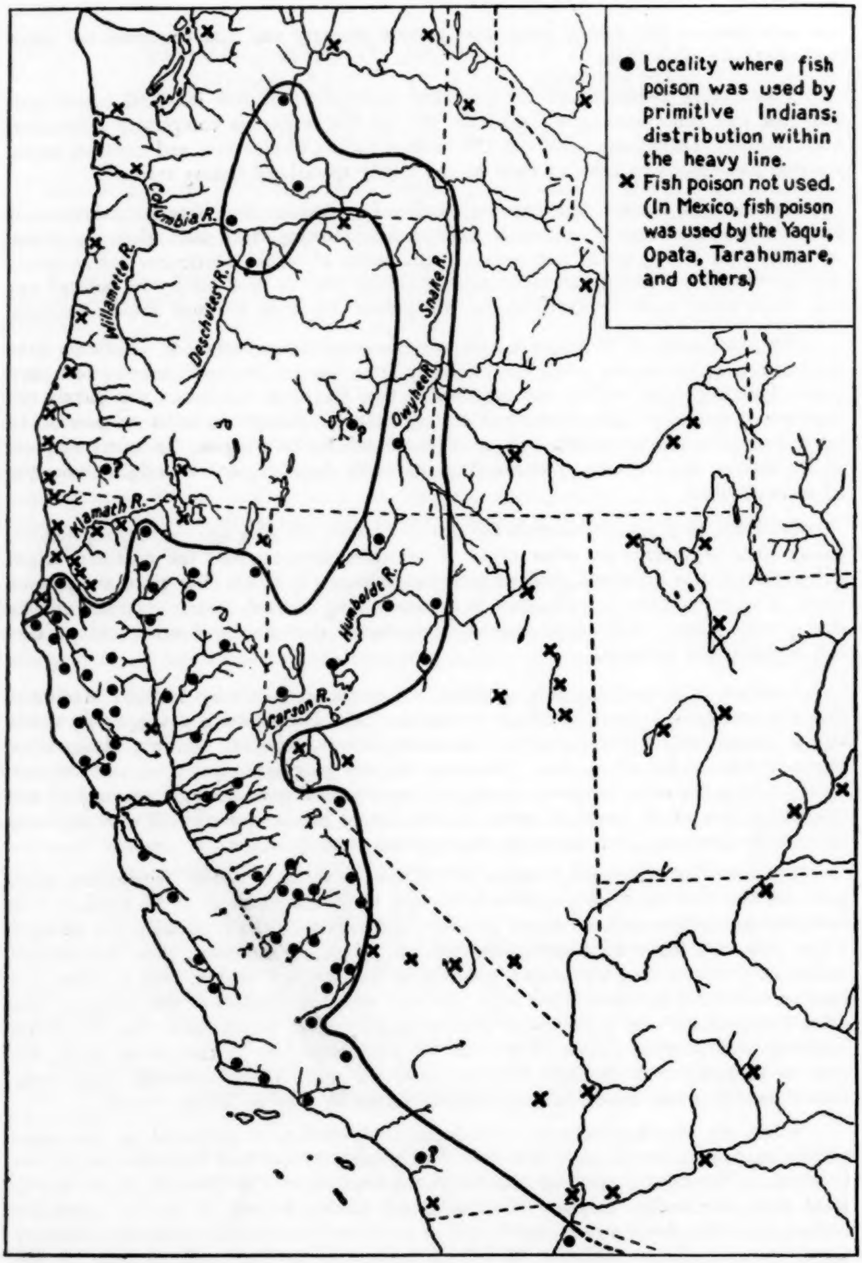

Fig. 1. Distribution of practice of fish poisoning among the Indians of the Pacific Coast states.

Klamath Rivers. The Dalles region, near the mouth of the Deschutes, has long been known as a lively cultural crossroad area, and it is enough for the present purpose to say that there are good arguments in favor of diffusion by this route.

The Willamette Valley is the third possibility, and it looks inviting from the north; but as a trail into California it becomes confused and blocked in the south. Anything coming up the Willamette would certainly have reached California, if it did, not by climbing the Siskiyous, but by being deflected either into the Klamath country or, and probably more likely, into the fourth of the possible routes, namely into the Oregon coastal streams. And concerning the coast route, it must be said that it clearly was a very important highway for the diffusion of many important fishing traits into California. Figure 2 provides an example.

By eliminating the unlikely water routes, along which the cultural evidence is negative or the water routes themselves improbable, there are thus left two major gateways into California, the coast and the Klamath. A final decision as to which of the two was the more important would require more detailed information and finer tools than the present study commands. A. L. Kroeber [6] believes that the Algonkinoid ancestors of the Yurok and the Wijot came by way of the Klamath route and the Athabascans from the north, presumably by the coast route. Both of these groups were, or at least in California became, skilled fishermen; but just how much fishing culture each brought in when it first came is another question. It must be kept in mind as a probability that earlier folk, who spoke Yuki, Hokan, and Penutian languages, also may have brought in fishing methods, perhaps the basic ones, and that later immigrants may have added only some new embroideries to the basic pattern.

The problems discussed thus far are relatively simple when compared with those that crop up within California. It is by digging among the fine roots of cultural geography that some queer and curious things are brought to light. Some of these are real problems, while others are undoubtedly no more than curiosities; and in both categories some striking parallels may be found in modern cultures.

For example, the lamprey was prized as a delicacy by the Yurok, but the Yana refused to eat it, believing it to be poisonous. In our times, northwest Europeans value the herring as a good fish, but it is certainly not relished by most North Amercians. The Shasta Valley Indians made use of fish poison, but their immediate neighbors, the Modoc on one side and the Karok on the other, did not. Along the Eel River, the Yuki and the Wijot had the gill net, but the record indicates that the Lassik, situated between the other two on the same river, did not. There is no record of the gill net among the Patwin and the Wintun, but all their neighbors used it. H. W:son Ahlmann [7] says that Norwegian fishermen, although they know the efficiency of the beam and otter trawls, are nevertheless, for reasons of their own, reluctant to adopt them. In Monterey one can observe Japanese deep-sea divers using lanyards and tying knots in preference to using the much more convenient strap and buckle employed by American divers. Some California Indians exploited their fish resources intensively, while others, with an excellent fish fauna at their front doors, seemed at best to be only casual fishermen. Such apparent indifference to a good food resource may also be found among Europeans. When Pedro Fages came to California he observed that the opportunity for fishing was so excellent that fish alone could have provided all the food for all the settlers the country could receive; yet no fishing of any importance arose. When Langsdorff and Beechey, separately, visited California, they both reported that the California Spaniards had obtained a special papal dispensation that permitted them to eat meat on fast days, on the ground that fish were very scarce. The scarcity was on the tables, not in the waters.

These irrational attitudes are not peculiar to primitive peoples; they are, rather,

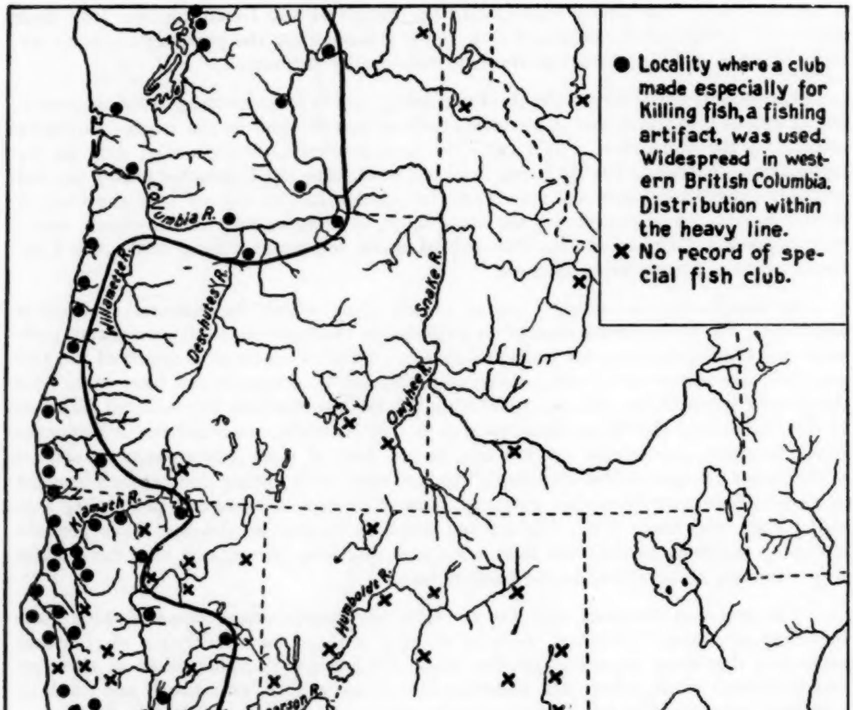

Fig. 2. Distribution of use of special club for killing fish among the Indians of the Pacific Coast states.

characteristic of all human cultures. Hence it seems reasonable to think that if an examination of primitive folk finds out something about the experiences, attitudes, and relations of one group of humanity to its natural resources, even though the group be called primitive, the findings may be useful in illuminating comparable relations in another group of humanity, even though it be called modern society. If that premise is sound, it logically follows that whoever as a cultural geographer limits his field of inquiry to the present-day world and disregards the evidence found among the primitives is thereby closing the door of a vast museum filled with laboratory specimens from the very field he purports to investigate.

The reason for an attitude called irrational is not always readily apparent; and when found it may turn out to be of a social, cultural, or psychological nature. Or it may be geographic. And it is surely the particular assignment of the geographer to ascertain whether or not the answer to a problem lies in geography or to establish the fact, if such be the case, that the explanation is not geographic.

Among the California aborigines, for example, there was a good physical reason for the absence of salmon ritual at Clear Lake, in Kings River, Calaveras River, or Pit River above Fall River: the salmon did not enter these waters. But the Karok at Clear Creek on the Klamath had plenty of salmon and no significant first-salmon ritual, and the explanation is that they felt that the ritual performed by the Yurok farther down the river took care of the matter. This reason is obviously not a matter of physical geography. There was no good reason in physical nature why the Modoc should not have used fish poison or the Patwin the gill net or why the California Spaniards should not have developed a significant fishing industry. It is obvious that a rich fishing culture must rest upon a good fish fauna, but it is equally clear that a rich fish fauna does not necessarily guarantee a flourishing fishing culture. It may seem trite in this day to emphasize the fallacy that lies in thinking or arguing from nature to culture, and the platitude is thrown in merely in order to turn it over so that we may look at the reverse side: it is also risky to argue from culture to nature. One of the culture traits of our society is the addiction to voluminous statistics, and there is of course no objection to statistics in their proper place; but the whole thing can easily go very wrong. For example, statistics are published at intervals on the commercial catch of fish and the regions where the fish were captured. This is useful information; it indicates that the major commercial fisheries of the world are in middle latitudes or northern waters. However, an embarrassing list of brand-new textbooks in geography repeat the old statement that tropical waters are poorer in fish than northern waters, or even blandly announce that the valuable food fishes live only in the higher latitudes; a conclusion that results from thinking is terms of statistics and not about the facts of nature. The ichthyologists are by no means so sure as are the economic geographers that tropical waters are poor in fish [8, 9, 10].

Another question may be cited, which probably interests all who are concerned with human culture and which recently and perhaps not too fortunately has been emphasized by press and radio: the relation between density of population and food supply. Assume for the sake of the argument that such a relation does exist. It can be said that wherever food is scarce there cannot be a dense population, unless, as in modern industrial society, the food is imported; but is it also true that wherever food is abundant the density of population must be high?

In native California, excluding the desert, which practically speaking lacked food fishes, there was no good correlation between density of population and abundance of fish. In fact, there were some examples of negative correlation. The reason for this poor correlation is at least partly clear. In the first place, the various tribes were not equally "fish-minded," and did not utilize the opportunity for fishing to the same degree of

intensity. In the second place, no people lived by fish alone, but also by food obtained from plants and land animals. The problem of forming an idea of a people's food supply must be attacked on three fronts: plants, land animals, and fish; and a painful shortcoming of the present study is that it has only one front.

In thinking about food and population in native North America, or for that matter in any other area and at any time, it is certainly necessary to have an estimate not only of the population but also of the food supply. It seems fruitless to think or talk about the reality or unreality of such things as Malthusian ceilings on population unless one has an idea of what the ceiling is. There are some fair figures for the aboriginal population of North America, but apparently very little has been done with the problem of evaluating its food supply, including its regional distribution. The task of working out the economic geography of the natural resources available to the earlier occupants of this land should appeal to geographers; for this work might throw a welcome light, not merely on the far-away Indian, but also on problems that persist in all human cultures.

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PROPOSAL FOR A MODIFICATION OF KOEPPEN'S DEFINITIONS OF THE DRY CLIMATES

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W. Köppen's classification of climates sets forth five major climatic regions, intended to correspond to the distribution of the major plant associations described by A. de Candolle. Boundaries of the climatic regions are defined quantitatively by monthly and annual means of temperature and precipitation. Köppen used these quantities in such a way as to take account of the effectiveness of precipitation, on the general principle that rate of evaporation from the ground and of transpiration from plants increases with temperature. That is to say, more precipitation is required in warm than in cool seasons or climates, if the water requirements of plants are to be met with equal effectiveness. This relation can readily be seen from Köppen's definitions of the dry climates [1], which, when mean annual precipitation, P, is expressed in inches as a function of mean annual temperature, T, in degrees Fahrenheit, are as follows:

	Mean annual precipitation at boundary between	
	Desert and steppe	Steppe and humid climates
Precipitation chiefly in winter	(1) $P = 0.22\ (T - 32.0)$	(4) $P = 0.44\ (T - 32.0)$
Seasonal contrast negligible	(2) $P = 0.22\ (T - 19.4)$	(5) $P = 0.44\ (T - 19.4)$
Precipitation chiefly in summer	(3) $P = 0.22\ (T - 6.8)$	(6) $P = 0.44\ (T - 6.8)$

Köppen divided the dry climates into two grades of intensity, steppe and desert, in such a manner that, with the same seasonal distribution, precipitation at the boundary between desert and steppe is only half that at the humid boundary of the steppe. Precipitation has a twofold relation to temperature: to mean annual temperature, and to the season in which most of the precipitation falls. Thus, along the boundaries of the dry climates, precipitation is heaviest where average annual temperature is highest and where most of the year's precipitation falls in the warm season. Both of these relations involve the prenciple of effectiveness of precipitation stated above.

Unfortunately, Köppen did not define the dry climates in such a way as to take account of changes in the seasonal concentration of precipitation along their boundaries. In their present form, therefore, the definitions of desert and steppe climates do not provide continuous boundaries of the dry climates. Each boundary is segmented, displaying offsets at the points where the precipitation régime changes [2].

The magnitude of these offsets is not inconsiderable; they amount to as much as 5.5 inches of precipitation along the boundary between the steppe and humid climates, and to half as much along the boundary between desert and steppe. Of Köppen's major climatic regions, only the dry climates show this objectionable lack of continuity. In the interest of logic, it would therefore seem desirable to modify the definitions of the dry climates so as to obtain continuous boundaries without arbitrary smoothing.

FORMULATION OF THE NEW DEFINITIONS

A start in this direction may be made by writing a general formula for the boundaries of the dry climates:

$$P = k\ (T \pm x), \tag{7}$$

in which P and T have the same meanings as in equations 1 to 6, k is a coefficient of proportionality having a value of 0.22 at the boundary between desert and steppe, and x is a variable whose value depends on the seasonal concentration of precipitation. An

appropriate definition of x based on the seasonal concentration of precipitation should complete equation 7 so that it will yield a reasonable and continuous delineation of the dry climates.

Instead of trying to establish a definition of x by trial and error, I have chosen to evaluate the effects of seasonality of precipitation by the use of monthly data, and to apply the results thus achieved in the form of a term suitable for use in the Köppen classification. Such a procedure can be conveniently carried out by reference to Thornthwaite's work on effectiveness of precipitation [3]. Thornthwaite found that a suitable index of "precipitation effectiveness" for a single month can be determined from the expression

$$I = 115 \left\{ \frac{P}{T - 10} \right\}^{10/9}, \tag{8}$$

in which I is the index of effectiveness of precipitation in a given month, P is mean monthly precipitation in inches, and T is mean monthly temperature in degrees Fahrenheit.

The sum of the twelve monthly indices computed by means of equation 8 is an annual index of effectiveness of precipitation. Thornthwaite defined the boundary of the desert by an annual index of 16, and the humid boundary of the steppe by one of 32. These boundaries are not much different from Köppen's, although differences in notation prevent the easy recognition of that fact. Reasonable assumptions can be made, however, which reduce the formulas to comparability.

If a station on the boundary of the desert climate is assumed to have a precipitation index of 16/12 in each month, the relation of precipitation to temperature may be expressed thus:

$$\frac{16}{12} = 115 \left\{ \frac{P}{T - 10} \right\}^{10/9},$$

$$\frac{P}{T - 10} = \left\{ \frac{16}{12} \cdot \frac{1}{115} \right\}^{9/10} = 0.0181,$$

$$P = 0.0181\ (T - 10). \tag{9}$$

Köppen's definition of the boundary of the desert climate may be tested under the same assumptions by choosing the equation that applies to precipitation distributed evenly through the year, namely equation 2. When divided by 12, this equation becomes

$$P' = 0.0183\ (T' - 19.4), \tag{10}$$

where P' and T' are monthly rather than the annual values that appear in equations 1 to 6.

Comparison of equations 9 and 10 show that Köppen's and Thornthwaite's definitions of the desert climate are quite similar. At a monthly temperature of 65°

Fahrenheit, Thornthwaite's definition demands, at the boundary between desert and steppe, an annual precipitation of 11.9 inches; Köppen's, 10.0 inches. It is to be expected, therefore, that Thornthwaite's desert area be somewhat larger than Köppen's. The steppe climates also occupy a larger area when delimited by Thornthwaite's instead of Köppen's definitions, since under the conditions of temperature assumed his formula gives, at the boundary betwen steppe and humid climates, an annual precipitation of 22.3 inches, whereas Köppen's gives 20.1 inches.

The discrepancies are not unduly large; I therefore decided to use Thornthwaite's formula, in order to gain the advantage of dealing with monthly data. Thereby the effects of differences in precipitation régime may be determined quantitatively. I assumed hypothetical distributions of temperature and precipitation through the year that are represented by sine curves and yield an annual index of 16. I then used these same values of temperature and precipitation, expressed in annual terms, with Köppen's definition of the boundary of the desert climate as written in equation 7. Thus numerical values of x were determined in relation to known seasonal concentrations of precipitation.

Only a little experimentation was needed to show that effectiveness of precipitation depends not only on its seasonal concentration, but also on seasonal contrasts in temperature, in addition to mean annual temperature. Since Köppen did not include a factor to accommodate seasonal contrasts in temperature, a comparison between Thornthwaite's and Köppen's formulas was of necessity conducted under the assumption of a constant annual range of 28° Fahrenheit. Where these conditions obtain along the boundary defined by values of 16 for Thornthwaite's index, the following equation gives a boundary between desert and steppe climates very similar to his:

$$P = 0.22\ (T - R/4), \tag{11}$$

in which P and T have the same meaning as in equations 1 to 6, and R is the percentage of the total annual precipitation that falls in the six winter months: October to March in the northern hemisphere.

If the boundary between steppe and humid climates in Köppen's classification is to be adjusted to the line formed by Thornthwaite's index of 32, the only modification of equation 11 required is in the coefficient of proportionality, which is increased by a factor of $2^{9/10}$. This operation gives, for the boundary between steppe and humid climates,

$$P = 0.41\ (T - R/4). \tag{12}$$

Equations 11 and 12 satisfy the aim of the present study, since they define desert and steppe climates in such a manner as to enclose areas having continuous boundaries, the positions of which are in reasonable agreement with those proposed in the past. The term R accommodates all possible seasonal concentrations of precipitation, and is simple enough to be in harmony with Köppen's approach to the classification of climates.

Comparison with Koeppen's and Thornthwaite's Boundaries

That my modifications of Köppen's definitions of the dry climates are directed toward closer agreement with Thornthwaite's than with Köppen's boundaries needs little apology. Thornthwaite and Köppen occupied common ground in defining the dry climates on the principle of effectiveness of precipitation; namely, that rate of loss of moisture from the soil increases with temperature, and hence must be balanced by increased precipitation if the water requirements of plants are to be supplied with equal effectiveness. This similarity of approach suggests that their delineation of the dry climates will agree closely. The improvement in this respect brought about by my modifications may be inferred from Table 1.

Table 1. Mean Annual Precipitation in Inches at the Boundary Between Desert and Steppe Climates According to Three Definitions[1]

	Köppen (Equations 1-3)	Thornthwaite (Index = 16)	Bailey (Equation 11)
Precipitation chiefly in winter	7.3	9.8	9.8
Seasonal contrast negligible	10.0	11.5	11.5
Precipitation chiefly in summer	12.8	12.9	13.3

1 Assumed: mean annual temperature, 65°F; annual range of temperature, 28°F.

For computing the values for Thornthwaite's index and from equation 11, the three precipitation régimes are defined by the following values of R: winter concentration, 81.2; absence of seasonal contrast, 50; and summer concentration, 18.8.

Even though equations 11 and 12 have been derived by a procedure based on Thornthwaite's definition of effectiveness of precipitation, perfect agreement with his boundaries can not be expected. Where the annual range of temperature is less than 28° Fahrenheit, equations 11 and 12 define boundaries that reduce the areas having desert and steppe climates, in comparison with Thornthwaite's definitions; an opposite departure yields relatively larger areas of the dry climates. Moreover, Thornthwaite treats months whose mean temperatures are below freezing by means of an empirical correction which results in an expansion of the dry climates. Such a procedure can not be easily applied to equations 11 and 12. Finally, since these equations refer to monthly data only to the extent of recognizing the precipitation régime, use of them will not yield results identical

Table 2. Mean Annual Precipitation in Inches Along the Boundaries of the Dry Climates According to Three Sets of Definitions[1]

	Mean annual precipitation at boundary between: Desert and steppe			Steppe and humid climates		
	K23	K28	B48	K23	K28	B48
Mean Annual Temperature 40° F:						
Precipitation chiefly in winter	5.2	1.8	4.4	10.5	3.5	8.2
Seasonal contrast negligible	7.4	4.5	6.0	14.8	9.1	11.3
Precipitation chiefly in summer	9.6	7.3	7.7	19.2	14.6	14.4
Mean Annual Temperature 60° F:						
Precipitation chiefly in winter	7.4	6.2	8.8	14.9	12.3	16.4
Seasonal contrast negligible	9.6	8.9	10.4	19.2	17.9	19.5
Precipitation chiefly in summer	11.8	11.7	12.1	23.6	23.4	22.6
Mean Annual Temperature 80° F:						
Precipitation chiefly in winter	9.6	10.6	13.2	19.3	21.1	24.6
Seasonal contrast negligible	11.8	13.3	14.8	23.6	26.6	27.7
Precipitation chiefly in summer	14.0	16.1	16.5	28.0	32.2	30.8

[1]Definitions (precipitation in inches: T, mean annual temperature in degrees F):

K23, Köppen's formulas of 1923 [3]:

	Mean annual precipitation at boundary between: Desert and steppe	Steppe and humid climates
Precipitation chiefly in winter	$0.11\ (T + 7.6)$	$0.22\ (T + 7.6)$
Seasonal contrast negligible	$0.11\ (T + 27.4)$	$0.22\ (T + 27.4)$
Precipitation chiefly in summer	$0.11\ (T + 47.2)$	$0.22\ (T + 47.2)$

K28, Köppen's formulas of 1928 and later, defined in equations 1 to 6.

B48, Köppen's formulas as modified in equations 11 and 12, with annual distribution of precipitation taken as follows: precipitation chiefly in winter, $R = 80$; seasonal contrast negligible, $R = 50$; precipitation chiefly in summer, $R = 20$.

with those obtained by summation of monthly data when the annual march of temperature and precipitation are irregular. Nevertheless, I believe that they represent the best agreement possible, in view of the difference in form between Thornthwaite's definitions and those I propose.

In comparison with Köppen's definitions of the dry climates, equations 11 and 12 expand the areas of desert and steppe somewhat, particularly in regions that receive a large percentage of their annual precipitation in winter. From the data given in Table 2, it is evident that the magnitude of the changes effected is no greater than Köppen himself introduced with the last revision of his definitions.

Classification of stations is facilitated by the use of suitable nomograms, such as those reproduced in Figure 1. The lines in *a* of the figure are computed from the equation $P = 0.22\ (T - R/4)$ and those in *b* from $P = 0.41\ (T - R/4)$, in which the terms have the meanings defined earlier, and R has the values entered along the respective diagonal lines. Only near a boundary, where a greater degree of accuracy is required than can be attained in nomograms of small scale, is it necessary to resort to the computations implied by equations 11 and 12.

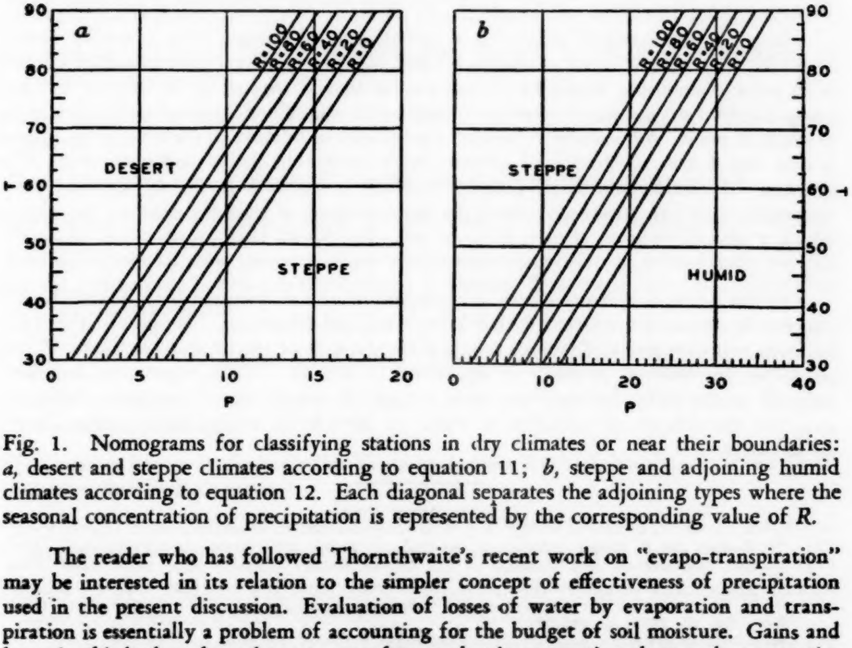

Fig. 1. Nomograms for classifying stations in dry climates or near their boundaries: *a*, desert and steppe climates according to equation 11; *b*, steppe and adjoining humid climates according to equation 12. Each diagonal separates the adjoining types where the seasonal concentration of precipitation is represented by the corresponding value of *R*.

The reader who has followed Thornthwaite's recent work on "evapo-transpiration" may be interested in its relation to the simpler concept of effectiveness of precipitation used in the present discussion. Evaluation of losses of water by evaporation and transpiration is essentially a problem of accounting for the budget of soil moisture. Gains and losses in this budget depend on so many factors that in computing them a clear appreciation of the climatic term, essential to a classification of climates intended for general use, is lost. Morever, it is quite possible that the climatic control of the soil-moisture budget may prove to be too incomplete to satisfy even those who have a special interest in the problem of soil moisture. This eventuality will leave the concept a useful tool in the solution of a larger problem, but again scarcely a satisfactory basis for the classification of climates. Hence, although I have not hesitated to relate Köppen's definitions of the dry climates to Thornthwaite's closely connected work on effectiveness of precipitation, I do hesitate to enter into the complexities of the problem of evaporation and transpiration as it affects the purpose of a classification of climates.

PURPOSE OF A CLASSIFICATION OF CLIMATES

In seeking a basis upon which to judge classifications of climates, Thornthwaite [5] has stressed the role of such terrestrial phenomena as the distribution of major soil groups and plant communities. The ideal classification, he holds, would portray boundaries that are faithfully reflected in the distribution of related terrestrial phenomena. Only a classification that fulfils this requirement, he argues, can be construed as depicting climatic wholes.

No one can deny the value of a classification of climates that would accomplish the object Thornthwaite has thus defined. In fact, mere speculation whether or not climatic controls exist is a matter of general interest. I would make one observation: the climatic classification whose boundaries are determined by reference to other terrestrial phenomena embodies a dual purpose. It purports to convey information about climate, and at the same time information about some related matter, usually distribution of some other terrestrial phenomenon. So completely has interest in such distributions monopolized the minds of some, that one finds maps of climatic regions delimited by quasi-quantitative terms: boundaries, in one part of a map, are defined by a climatic quantity, in another by a terrestrial feature indefinable in climatic terms.

Is it not reasonable to insist that a classification of climate furnish readily understandable information about climate? I think so. So conceived, correlation of climate with other phenomena would be carried out in such a manner as to convey an easy comprehension of the distribution of climates as such. The Köppen classification is an example in point. Admittedly of limited significance in relation to the ecology of plants, it does depict the distribution of climates with acceptable clarity and pertinence. The synthesis of climate and plant geography which it presents is, in my opinion, more successful than later proposals having the same purpose, at least for most of the uses to which a classification of climate is to be put. It follows that proposals to refine the Köppen classification gain in significance if they are in harmony with Köppen's approach.

In the proposal advanced here, a conscious effort has been made to define the dry climates in a manner consistent with Köppen's original definitions. The goal of the study has been imporvement of Köppen's notation for the sake of clarity and simplicity. These properties are believed to reside in equations 11 and 12. Little importance has been assigned to the shifts in boundaries that attend the use of these equations. Adequate data for the defense or rejection of shifts in boundaries within such narrow limits do not exist.

LITERATURE CITED

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[2] Richard Joel Russell, Dry Climates of the United States: Climatic Map, Univ. Calif. Publ. in Geogr., Vol. 5, No. 1, pp. 1-41, 1931. Reference to pp. 17-18 and Fig. 3, p. 17.
[3] C. W. Thornthwaite, The Climates of North America According to a New Classification, Geogr. Rev., Vol. 21, 1931, pp. 633-655.
[4] Idem, The Quantitative Determination of Climate, ibid., Vol. 22, 1932, pp. 323-325.
[5] Idem, Problems in the Classification of Climates, ibid., Vol. 33, 1943, pp. 233-255.

THE ASSOCIATION OF PACIFIC COAST GEOGRAPHERS

Summer Conference, Seattle, Washington, August 15-16, 1947

A Summer Conference, supplementary to the annual meeting of the Association at San Diego in June, 1947, was held in Seattle on August 15 and 16. The Conference included three half-day sessions for the reading of papers, which convened in Room 401, Social Sciences Building, University of Washington, in the forenoon and afternoon of Friday, August 15, and the forenoon of Saturday, August 16. A dinner session was held on Friday evening in the Meany Hotel..

PROGRAM

Friday Morning Session, August 15

Land Use Levels in Boundary County, Idaho. Howard J. Crutchfield, Washington State College, Pullman.

Mercer Island. Robert Young, University of Washington, Seattle.

The Roslyn-Cle Elum Coal Field. John O. Dart, University of Washington, Seattle.

Conservation of Forests Through Multiple Use. Joseph T. Hazard, Department of Public Land, Olympia.

Potato Industry of Kittitas Valley. Edward Whitley, University of Washington, Seattle.

The St. Lawrence Seaway. Roger E. Erwin, University of Washington, Seattle.

The Russian-Polish Borderland. Ann Remington, Syracuse University, Syracuse, New York.

Factors Influencing Tourism in the Olympic Peninsula. Samuel C. Dashiel, University of Washington, Seattle.

Friday Afternoon Session, August 15

Change in Arabia: Hadhramaut. J. Allen Tower, Birmingham-Southern College, Birmingham, Alabama.

The Location Factor in the Early Fur Trade of Astoria. Ruth E. Cross, Lewis and Clark College, Portland, Oregon.

Geographical Implications of Schistosomiasis in the Yangtze Delta. Lilliam P. Johnson, Syracuse University, Syracuse, New York.

Human Energy, Physical and Emotional, Under Varying Weather Conditions. Lucile Carlson, Western Reserve University, Cleveland Ohio.

Abstract: The investigation of which this is a summary account was an effort to discover some of the effects exerted on human beings by daily changes in weather. The observations were made at Minot, North Dakota, between November and June. Weather observations made three times a day were obtained from the local weather station. Three aspects of energy, mental, emotional, and physical, were observed; of these only the last two are considered here. The measures of physical energy used were the Tuttle pulse ratio test, the Navy physical fitness test, and the time required for pedestrians to traverse a fixed distance. As a measure of emotional energy, the number of fights occurring on the playgrounds of six schools was used. The effects of wind speed, temperature, air pressure, and cooling power on behavior were separately subjected to statistical treatment. "Air

pressure" is local surface pressure, not reduced to sea level. "Cooling power" was computed from the formula $(0.15+0.18\sqrt{V})\ (98°\text{-}T)$, where V is wind speed in miles per hour and T is air temperature in degrees Fahrenheit. One or more experiments were made for each class of behavior under diverse weather conditions The results may be summarized as follows:

Temperature. 1. Low temperature appears to stimulate physical energy and to depress emotional behavior. 2. The output of physical energy appears to become progressively less as temperature rises. 3. Moderately low temperature causes emotions to rise. 4. At the temperatures designated by Ellsworth Huntington as the "optimum temperatures for work," emotions tend to be stable and physical output steady.

Wind speed. 1. Increase in wind speed produces a parallel increase in physical energy. 2. High and low, but especially high, speed seems to intensify emotional reactions. Moderate speed seems to induce an even disposition.

Cooling power. 1. Physical energy increases as cooling power rises. 2. When cooling power is either very high or very low, emotional response is heightened. 3. There is probably an optimum cooling power, between 70 and 79 degrees, for the highest expression of energy.

Air pressure.. 1. When pressure is close to the mean, emotions remain steady; as it rises above or fall below the mean, emotional behavior become markedly more intense. 2. The higher the pressure, the longer the period required for the pulse to return to normal. 3. Low or high pressure appears to be more stimulating to physical energy than does pressure near the mean.

It can be predicted that as cooling power and, within limits, wind speed increase, individuals will expend more energy. As pressure becomes very high or very low, tempers and group tensions mount. As temperature rises, on the average, energy output can be expected to diminish. When wind speed becomes high, it can be expected, though with less assurance than in the case of cooling power and pressure, that people will become more sensitive, uneasy, and irritable.

The Geographic Factor in the Growth of Saskatoon. WILFRED G. MYATT, University of Washington, Seattle.

The Urban Landscape of Port Townsend. H. LEE COMBS, Oregon State College, Corvallis.

The Humboldt River and Its Influences on the Forty-Niners. JOHN THOMPSON, University of Nevada, Reno.

A Köppen Classifiction for Eastern Washington. JOHN C. SHERMAN, University of Washington, Seattle.

DINNER MEETING, AUGUST 15

Fallacies Regarding Latin America. DAN STANISLAWSKI, University of Washington, Seattle.

The Northwest Indian in Fact and Fictien. ERNA GUNTHER.

The Northwest Logger in Fact and Fiction. JAMES STEVENS.

SATURDAY FORENOON SESSION, AUGUST 16

Duluth-Superior: the American Lakehead. STANLEY ARBINGAST, University of Washington, Seattle.

Community Structure in the Northwest Logging Camp. MARGARET CARSTAIRS, Public Schools, Seattle, Washington.

Whidby Island, a Study in Modified Insularity. FRED G. BUERSTATTE, University of Washington, Seattle.

Alviso: Quondam Port for the Santa Clara Valley. DALE V. GRAVES, Stanford University, California.

Ellen Churchill Semple. RUTH E. BAUGH, University of California, Los Angeles.

The Sequim-Dungeness Valley Lowland. DOUGLAS B. CARTER, University of Washington, Seattle.

Flax for Fiber in the Willamette Valley. J. GRANVILLE JENSEN, Oregon State College, Corvallis.

ELEVENTH ANNUAL MEETING, BERKELEY, CALIFORNIA, JUNE 24-26, 1948

The Association held its eleventh annual meeting in conjunction with the annual meeting for 1948 of the Pacific Division, American Association for the Advancement of Science, on the campus of the University of California, Berkeley. Four half-day sessions for the presentation of papers were held in Room 217, Hilgard Hall, on June 24 and 25. The annual business meeting followed a short program of papers at the forenoon session of June 25. The annual dinner, at which the address of the retiring president was delivered, was held at the Hotel Shattuck in the evening of June 24. Two excursions in the San Francisco Bay area were arranged for the forenoon and afternoon of June 26.

PROGRAM, WITH ABSTRACTS OF PAPERS PRESENTED

(Papers published in full in the foregoing pages are not abstracted here.)

THURSDAY MORNING SESSION, JUNE 24

Natural Resources of the Palau Islands. WOODROW R. CLEVINGER, Lieutenant Commander, United States Naval Reserve.

Abstract: The Palau Islands lie within a rectangle bounded by the parallels of 7 and 8 degrees north latitude and the meridians of 134 and 135 degrees east longitude. They have a rainy tropical climate with a slight seasonal rhythm imposed by the Asiatic monsoon. The archipelago consists of 26 basalt and limestone islands having a combined area of 188 square miles. The native population numbers about 8,000.

As a part of the Trust Territory of the Pacific Islands, the Palaus are at present under the jurisdiction of the United States Navy, which is represented by an administrative and advisory colony of one hundred Americans, concentrated on Koror Island. This administration is organizing a new economy, oriented toward America, to replace the one built up under the Japanese mandate. Under Japanese occupation, the economy was dominated by 25,000 Japanese colonists, who were repatriated soon after the end of the second World War.

The first responsibility of the administration is a strengthening of the native economy, which is based on fishing and agriculture. Beyond the range of the native economy, the islands contain an abundance of natural resources, exploitation of which depends on the application of imported capital and technology. The sea offers pelagic fisheries of tuna and mackeral, and in littoral waters shellfish of commercial value. A limited area of suitable soils provides opportunity for commercial tropical agriculture. Under the Japanese occupation, about 2,000 acres were planted to pineapples, tapioca, and tree crops, in addition to experimental plots of other tropical and subtropical plants. The upland forests are capable of supplying tropical hardwoods. The most important of the resources of the islands, however, are mineral, consisting of deposits of phosphate rock and bauxite. The Japanese removed 2,000,000 tons of phosphate rock from Angaur

Island, at the southern end of the archipelago, but a million tons remain. In northern Babelthuap Island is a deposit of bauxite suited to open-pit mining, estimated to contain 50,000,000 tons.

Land Utilization on Saipan. J. L. TAYLOR, Stanford University, California.

Abstract: Saipan, at present the headquarters of the Northern Marianas District of the American Trust Territory of the Pacific, is a rugged island, built of coralline and volcanic rocks, and situated 125 miles north of Guam. Sixty percent of its surface is too rugged for cultivation, and elsewhere the thinness and immaturity of the soils restrict their productivity. Its marine subtropical climate permits, however, the production of a wide range of crops on the cultivable land. Under the Japanese occupation, the island produced large quantities of sugar and copra. But at present the sugar plantations, deprived of the subsidy that formerly maintained them, can not compete with American sources of sugar. Storms, disease, pests, and the ravages of war ruined the coconut plantations, and it has not been profitable to replant them.

The economic activities of the inhabitants of the island, who comprise four thousand Chamorros and one thousand Carolinians, are therefore restricted to the production of goods for local consumption and work for the naval establishments on the island. Their productive work for the local market includes farming, fishing, and handicraft. Small plots, individually tilled by hand, produce sweet potatoes, corn, beans, leafy vegetables, bananas, and papayas.

Land-Use Planning and the Colville Valley, Washington. FRANCIS J. SCHADEGG, Eastern Washington College of Education, Cheney.

Abstract: Colville Valley is cited here for the purpose of demonstrating how a geographer can contribute to the planning of use of the land by making an inventory of the resources of a region, analyzing the facts collected, and suggesting courses of action.

Beginning at a point 40 miles south of Spokane, Colville Valley slopes northward 50 miles to Roosevelt Lake, occupying an area of about 800 square miles. It includes a series of basins crossed and flanked by low mountains that rise 1500 to 2000 feet above them, and is bordered on the east and west by mountains rising 5000 feet above the valey floor. The lowlands and tributary valleys, to a height of 3000 feet, have a thick mantle of glacial drift and outwash. Lake sediments, deposited in marginal glacial lakes that stood 2500 to 3000 feet above sea-level, form the floor of much of the main part of the valley. These lake sediments form the soils that are best suited to agriculture. In addition, some sub-irrigated outwash soils are cultivable; other, because of excessive drainage, are not. The adjoining mountains provide range and forest lands. Successful farming in the valley requires careful management, with overhead irrigation in some places and drainage in others.

The climate of the valley is moderately severe. Three winter months have mean temperatures below freezing; July and August average 65 degrees Fahrenheit. The mean growing season is 125 days, varying locally as much as two weeks above and below this mean. Mean annual precipitation is 16 inches, most of which falls in the winter half of the year. In July and August, on the average, the precipitation amounts to less than an inch.

There is a limited store of mineral deposits, the most important of which is magnesite. The forests of the valleys are depleted, but yield yellow pine and cottonwood of commercial importance. They will require careful management in the future. Opportunities for recreation include excellent fishing, hunting, winter sports, and summer resorts, and may be expanded in the future. The valley is advantageously situated within 100 miles of both Grand Coulee Dam and Spokane, a rapidly growing industrial and trading center. Its deficiences in soil, relief, and water-supply impose special precautions in the classification of land and evaluation of its productvity.

Land Utilization in the Livermore Valley. DAVID LOWENTHAL, University of California, Berkeley.

Abstract: Livermore Valley, in the eastern part of Alameda County, California, is an isolated area that lies entirely within the hills of the central Coast Range. In it, diversity of land utilization contrasts sharply with physiographic homogeneity. Thirteen miles long and four to five miles wide, the flat valley floor slopes gently from east to west, draining by small streams entrenched in arroyos twenty to forty feet deep through Amador Valley and past Sunol toward the southern end of San Francisco Bay. Alluviation of the valley floor was effected mainly by streams entering from the southeast.

The distribution of crops in the valley is primarily a function of the depositional sequence of the soils. In the south, on the material first deposited by the aggrading streams, vineyards occupy the lower gravelly slopes near the major streams. Commercial gravel works occupy land farther north and downstream, where the gravel is finer. On the sandy and clayey loams of the central part of the valley, row crops flourish; the minimal slope is here favorable for the raising of sugar beets, roses, and tomatoes under irrigation. On the heavy clay or alkali soils of the northern part, small grains are grown: barley for brewing or hay, oats, and some wheat. Livestock grazes on the residual soils of the foothills all around the valley and in the bottoms of the arroyos inside it.

The Agricultural and Economic Conditions of Egypt. H. O. N. BULL, Lewis and Clark College, Portland, Oregon.

Abstract: The inhabitants of the Near East as a whole are rural, in the main illiterate, undernourished, and oppressed by the curses of the region: drought, debt, and a bad system of land tenure. Yet in spite of everything the population is increasing at a higher rate than in any other part of the earth. Egypt forms no exception to these generalizations. In Roman times Egypt had a population between six and seven millions, but by 1798 war, disease, starvation and Turkish massacres had reduced it to two-and-a-half millions. Since then the population has increased steadily, and by 1950 it should be nearly twenty millions. About two-thirds of this population depend on agriculture for a living; and this fact raises the first problem. Ninety-seven percent of Egypt is desert, the only large agricultural area being the Nile Valley. In 1940, slightly more than six million acres were cultivated. From this area fourteen million agriculturists scratched a living, by primitive methods. At least one third of the land was held by large landowners, who paid very low wages for farm work. The condition of the peasants was wretched. Starvation and disease held them down and there seemed to be no chance of improvement. The wealthy class ascribed the bad conditions of the country to the evils of British occupation, but this has now ended and no improvement can be seen.

Of late years Egypt has put forward a somewhat haphazard program of industrialization. This has provided work for many who were previously unemployed, but the departure of the occupation forces has thrown many more out of work. The only solutions to these problems are education, birth control, extension of the area under cultivation, and above all emigration. The one country that could take the surplus population is Iraq, and here scientific irrigation would have first to be established. Political issues are also involved. One fact stands out: unless Egypt can find work and a better living for its people a revolution will occur within two decades.

World Distribution of Avocado Growing. DONALD I. EIDEMILLER, University of California, Berkeley.

Abstract: The cultivated species of the avocado (*Persea americana*) are indigenous to Mexico, Central America, and South America. Of these cultivated forms three distinct types are recognized, Mexican, Guatemalan, and West Indian. There are hybrids between Mexican and Guatemalan, and between Guatemalan and West Indian types. Because

the avocado is a subtropical fruit, its culture is limited to areas in which winters are mild and spring and summer temperatures are not high.

After the Spanish conquest of the Americas, the avocado was introduced into Cuba, and at a later date it spread throughout the West Indies. It was introduced into Florida and California in the nineteenth century. It did not become commercially important, however, until after 1920. Dissemination into other parts of the earth began only after commercial success in these two areas had been achieved. Its spread was slow, plantings being made only experimentally.

Today, the distribution of avocado culture over the earth can be divided as follows:

Principal commercial areas (large-scale production for the domestic market and export, orchard planting): California (hybrid); Florida (West Indian); and Cuba (West Indian).

Secondary commercial areas (small commercial production, primarily for local consumption): West Indies (West Indian); Panama (West Indian); Brazil (hybrid and Guatemalan); Paraguay (West Indian); Argentina (Mexican); Chile (Mexican); Morocco, Algeria, Egypt, Palestine, Greece, Sicily, and France (Mexican, hybrid, and Guatemalan); South Africa and Madagascar (West Indian); Southern Russia (Mexican, hybrid, and Guatemalan); India, Ceylon, Burma, Indo-China, Malay States, Java, southern China, Formosa, and Philippines (all types); Australia (West Indian); New Caledonia, Fiji, Samoa, Tahiti, and Guam (West Indian, hybrid, and Guatemalan); Hawaii (West Indian and Guatemalan).

Non-commercial areas (semi-cultivated, not grown as a commercial enterprise): Guatemala (Guatemalan); Honduras, San Salvador, Nicaragua, Costa Rice, Colombia, Ecuador, Peru, Venezuela, and the Guianas (West Indian).

Diversified commercial area (large production for the domestic market, both orchard and semi-cultivated plantings): Mexico (all types).

The Distribution of Settlements in the United States. WILBUR ZELINSKY, University of California, Berkeley.

Abstract: The data examined included (1), number of square miles per agglomerated settlement, excluding metropolitan areas, and (2), number of square miles per agglomerated settlement, excluding metropolitan areas and hamlets containing only 20 to 140 inhabitants. These ratios were computed and mapped by counties.

The largest area in which agglomerated settlements are dense includes the great conurbation that reaches from Boston to Philadelphia, stretches westward across Pennsylvania, and then turns southward through central West Virginia and eastern Kentucky. The entire Appalachian area is astonishingly well supplied with hamlets and villages. The greatest density in the United States is found along the western shore of Chesapeake Bay. In general there is a good correlation between density of population and density of non-metropolitan agglomerated settlements. But the Southeast is conspicuosly deficient in such settlements, especially if hamlets are excluded. A number of other, minor anomalies are found.

From examination of the maps it appears that the number of agglomerated settlements in an area varies with the density of rural population and its wealth, measured by value of land and buildings. The effects of relief of the land surface on density of the settlements are not simple. In general terms, it may be said that agglomerated settlements become denser as relief becomes greater where agriculture is practiced, but where it is impracticable the number of settlements per unit area is diminished by high relief. The fraction of agglomerated settlements of "hamlet' size increases with roughness of terrain and diminishing economic opportunity.

Traffic on the Missouri River. SIDNEY E. EKBLAW, University of Kansas City, Kansas City, Missouri. .

Abstract: The Missouri River, extending 2,465 miles from its source in the Rocky

Mountains to its mouth at the Mississippi, was the main avenue to the territory between the Mississippi and the Pacific utilized by explorers, fur traders, and pioneer settlers. Before it succumbed to competition with the improved transportation offered by the railroads, beginning in the eighteen-sixties, thousands of tons of food, construction materials, and trading goods were transported westward and northward on the Missouri; thousands of tons of furs, grain, lumber, and raw materials floated downstream on it; and thousands of passengers passed up and down its length.

Increased settlement in the Missouri Valley, establishment of a grain and livestock empire within its drainage basin, and the rise of hundreds of factories and warehouses along its banks created new problems of flood control, erosion of soil and stream banks, irrigation, domestic water supply, generation of electric power, preservation of wildlife, and sewage disposal; and in addition reawakened interest in the use of the river as an artery of transportation. Accordingly, Congress approved the Pick-Sloan plan for development of the river, authorizing an expenditure of $70,000,000 for reservoirs, agricultural and municipal levees, irrigation systems to water more than five million acres, and hydroelectric plants; and specifically authorizing the construction of a nine-foot channel between Sioux City and the mouth of the Missouri. In 1946, 1,027,000 tons of cargo moved 45,000,000 ton miles over this section of the river.

THURSDAY AFTERNOON SESSION, JUNE 24:

Dundee, A Scottish City. STANLEY J. JONES, University College, Dundee, Scotland. Published in full in this issue.

Theory of Mountain and Valley Winds. H. BOWMAN HAWKES, University of Utah, Salt Lake City.

Abstract: Diurnal mountain winds have been discussed in meteorological literature for the past three quarters of a century under the designation "mountain and valley winds." In the light of recent research, this old and well established term appears inadequate. The winds that are produced thermally in country of high relief must be separated into two systems; namely, (1) valley winds and (2) slope winds.

Valley winds are winds that move along the longitudinal axis of a valley, induced by a temperature difference between a column of air over the valley and a column at the same elevation over the adjacent plain. The local wind that moves up the valley by day is the "up-valley wind," whereas the wind that moves down the valley by night is the "down-valley wind."

Slope winds are found along the slopes of all relief features of the land. They follow the inclination of the slope, and are induced thermally by a difference in temperature between the air resting on the slope and the free air above the adjacent plain or valley. Local diurnal winds that move up the slope by day and down the slope by night are "up-slope" and "down-slope" winds respectively.

Valley winds and slope winds are highly localized phenomena, yet they are widely distributed in space and time. They appear in all hilly or mountainous lands. Their intensity and behavior differ, however, according to relief and slope. They occur at all seasons and under all weather conditions in mountain areas, but their depth and steadiness attain a maximum only on clear days in summer when gradient winds are weak.

The Normal Annual March of Precipitation in California. JOHN LEIGHLY, University of California, Berkeley.

Abstract: It is possible to define the familiar distribution of precipitation through the year in California, characterized by a dry summer and a rainy winter, more precisely than by such general terms. The difference in annual total between the rainy and the dry parts of the state can be eliminated by computing the precipitation of each month as a percentage of the annual total from July 1 to June 30. When so computed, average monthly percentages show remarkable uniformity over the parts of California

that lie west of the Sierra Nevada and the mountains south of the Tehachapi. East of the mountains, and especially in the far southeast, the appreciable fraction of the annual total of rain that falls in summer excludes these parts of the state from the region that has the characteristic Californian seasonal distribution.

A general mean for the state may be computed for the 60-year period 1885-86 to 1944-45, for which unbroken records are available from 36 stations within the parts of the state that have the typical California régime. In this general average, 25 percent of the year's precipitation falls by December 16, 50 percent by January 24, and 75 percent by March 4. Half of the year's total thus falls, on the average, in the period of slightly more than two and a half months between the middle of December and the first week in March.

This general average provides a standard for comparing the distribution of precipitation through the year among the several parts of the state and among different years. Within California, the rainest period occurs early in the winter in the north, and becomes progressively later as one goes southward. It is evident from the record that one must recognize, in addition to the factor of atmospheric circulation that favors a midwinter maximum, namely the occurrence of cyclonic storms in these latitudes, another factor, also at its maximum in midwinter, that inhibits precipitation. This factor expresses itself on the weather map in the form of persistent high pressure over the Great Basin, and affects southern California more often than it does the central and northern parts of the state. In the past two winters it has, however, strongly affected the whole of California, producing a dry midwinter between a rainer early winter and spring.

A Terrain Sample of the Sierra Crest Region. DAVID H. MILLER, Coöperative Snow Investigations, United States Corps of Engineers, Oakland, California.

Abstract: Coöperative Snow Investigations, a joint undertaking of the Corps of Engineers and the Weather Bureau, is engaged in the study, through special observations in selected mountain basins, of floods resulting from melting of snow. For the sake both of control of experiments and of possible transfer of results to other basins, the analysis of such observations requires specific information, expressed when possible in quantitative terms, on the physical characteristics of the basins. The Central Sierra Snow Laboratory, near Donner Summit, California, occupies one of these basins. It is situated at the headwaters of the South Fork of Yuba River, and has an area of four square miles. Its surface is moderately rolling, developed partly on granite and partly on agglomerate, and has been glaciated. It is composed of three heights of volcanic rock separated by two wide valleys which form an elbow at its eastern side. Below 8,000 feet, it is covered by sub-alpine lodgepole pine and associated meadows, isolated stands of fir, grassy glades, and brush. The following paragraph gives some of the numerical characteristics of the basin, as a specimen of the kind of information required in the snow investigations, and as a sample of the quantitative characterization of a region. The basin is divided into smaller topographic units, each of which is fairly uniform in character, and in which the mean numerical values are more significant than those determined for the whole basin.

Mean slope, 24 percent, with standard deviation 18 percent. Mean orientation of slope, 193 degrees azimuth. Direct insolation on the component topographic units, 90 to 102 percent of that on a horizontal surface. Maximum elevation, Castle Peak, 9105 feet; mean elevation, 7500 feet; 73 percent of the basin lies between 7,000 and 8,000 feet. Percent of surface having concave vertical profile, 43 percent; convex, 27 percent. Covered by forest canopy, 19 perent. Number of streams (all intermittent), 102. They are grouped into the following orders: first order ("finger-tip"), 79; second order, 18; third order, 4; fourth order, 1 (Castle Creek). Density of channels, 9 miles per square mile of area. Mean distance of overland flow of water, 385 feet. Gradient of mean stream, 4 percent; of tributaries, 15 to 20 percent. Ratio of slope of land surface

to gradient of streams, about 1.5. Maximum time of travel of water to outlet of basin, 2.2 hours. There are two modes of travel time, at 0.7 and 1.4 hours, corresponding to the lower and upper sub-basins, respectively.

New Climatic Maps. SAMUEL VAN VALKENBURG, Clark University, Worcester, Massachusetts. (No abstract.)

Proposal for a Modification of Köppen's Definitions of the Dry Climates. HARRY P. BAILEY, University of California, Los Angeles. Published in full in this issue.

Rubber Terrain Models (Navy Training Film.) WOODROW R. CLEVINGER, Lieutenant Commander, United States Naval Reserve.

Abstract: During the second World War the United States Navy produced rubber terrain models in quantity to meet the practical need for light, portable, and durable three-dimensional maps for combat use by surface and shore forces. These models were superior to military topographic maps in the warfare of the Pacific, fought on islands and in rain forest. The models were made in a large laboratory in Washington, D. C. The first step in making a series of models of a particular area was the construction of a conventional relief model in plaster of Paris from topographic maps or aerial photographs. A mold was then cast from this model, filled with liquid lastex, and bodied with nuprene foam rubber, then baked in an electric oven for one hour at 260 degrees Fahrenheit. After the rubber model was removed from the mold, the details of physical and cultural geography were applied in moisture-resistant colors so as to approximate the color and texture of the landscape.

Models of small areas, such as islands and beaches, were generally made on a scale of 1:15,000; because of the great importance of mountains and hills to troops, the vertical scale was exaggerated by a ratio of eight to one. Models of large areas or parts of continents were made in matching sections, on scales that ranged from 1:50,000 to 1:1,000,000.

The process is adaptable to university laboratories for producing visual aids in teaching geography. The largest items of expense would be the cost of installing a baking oven and of equipment for mixing the rubber.

THURSDAY EVENING, JUNE 24:

Annual Dinner, Hotel Shattuck. Address of the retiring President: In Defense of the Sugar-Beet Industry of the Western United States. HAROLD A. HOFFMEISTER, University of Colorado, Boulder. Published in full in this issue.

FRIDAY FORENOON SESSION, JUNE 25:

Duwamish River: Its Place in the Seattle Industrial Plan. S. LUCILE CARLSON, Western Reserve University, Cleveland, Ohio.

Abstract: The industrial investment per capita in three leading cities on the Pacific coast of the United States is as follows: Los Angeles, $26.48; San Francisco, $42.66; and Seattle, $80.95. Although the total industrial investment in Seattle is less than in the other cities named, its ratio to population is thus much larger. The expansion of industry and growth of population in Seattle presents a difficult problem, although enterprises that demand large areas are not so characteristic of Seattle as are those that have large payrolls but require only a moderate amount of space.

Situated as Seattle is on a series of lakes and hills, many difficulties have had to be overcome if business was to be transacted with facility and industry find adequate sites. The problem has been, and is being, satisfactorily solved. Hills have been leveled, tidal flats filled, and the tortuous Duwamish River, which periodically floods the land adajacent to it, has been made safe by partial straightening.

Industry has spread southward into the reclaimed area. At the present rate of construction, building sites within the city are sufficient for industrial expansion only through 1950. Much land well suited to industry is found in the Duwamish

Valley beyond the region now occupied, and also in the valleys of the Cedar, Green, and Black rivers, directly adjacent to the Duwamish. Expansion on to this land awaits flood control, a plan for which is now before the appropriate federal agencies.

The Geography of Eugene. WARREN D. SMITH, University of Oregon, Eugene.

Abstract: At the present time, the population of Eugene is probably changing more rapidly than that of any other city in Oregon. A geographic appraisal of its site and surroundings is therefore appropriate. Two additional important considerations are these: Eugene is now the focus of the lumber industry on the Pacific coast and perhaps in the country in general; and because of its situation on the banks of the Willamette it has for many years been menaced by serious floods.

Industrial Development of the San Francisco Bay Area. JAMES J. PARSONS, University of California, Berkeley.

Abstract: Despite its earlier start, the San Francisco Bay area now occupies a position second to Los Angeles as an industrial center. Only in shipbuilding and canning does it stand first. Most of the new factories established in the Bay area in recent years have been branch plants of established national concerns, and many of the older independent establishments have been absorbed by eastern interests. Several of the more successful local firms have moved their manufacturing operations to the east, to sites closer to the major markets.

A map representing the distribution of manufacturing establishments of the Bay region that employ more than one hundred persons each shows a wide dispersion from San Francisco eastward to Antioch and southward to San Jose. The plants are aligned along the routes of the main railways. These generally hug the tidal shores of the Bay, where level land has been cheap and sewage disposal easy. Deep-water shipping channels have been only a secondary attraction. Thirty of the 42 larger plants, which employ more than 500 workers each, are situated in the East Bay counties, Alameda and Contra Costa.

Increase in population has outsripped growth of manufacturing, so that the fraction of the total population of the Bay area employed as production workers in industry has remained at a relatively low level, compared with the metropolitan areas of the Eastern manufacturing belt. In the five counties of the San Francisco-Oakland industrial area, factory employment increased by 32 percent between 1929 and 1947, while population showed a gain of 45 percent. This rate of growth is appreciably below that of the state as a whole, where factory jobs increased by 66 percent and population by 74 percent during the same period. Diminishing reserves of oil and gas, power shortages in years of nearly normal rainfall, and the high cost and limited quantity of available fresh water are forewarnings that the resource pattern of the state cannot permanently support the present rate of expansion.

Notes on Early Routes to California. HOWARD H. MARTIN, University of Washington, Seattle. (Read by title.)

Fishing Among Primitive Peoples: a Theme in Cultural Geography. ERHARD ROSTLUND, University of California, Berkeley. Published in full in this issue.

The Pre-European Peoples of New Zealand. EDNA M. GUEFFROY. University of Washington, Seattle.

Abstract: Any attempt to reconstruct the life of the early occupants of New Zealand, prior to the years of discovery by Tasman and Cook, must rest largely upon archeologic evidence, native genealogic records, and legends orally transmitted from generation to generation. It is obvious that a speculative element must enter into a historico-geographic interpretation.

Although it is recorded that the islands were sparsely inhabited by "true Maoris" as early as 850 A.D., the main tide of migration from the Society Islands did not start

until the middle of the fourteenth century. The North Island proved more attractive to the immigrants than did the South Island. This selection reflects not only increasing distance from tropical Tahiti, but also the unsuitability of Maori ways of living to the cooler summer and sterner winter of the higher southern latitudes. The Polynesian culture, essentially that of a lowland agricultural and fishing people, sought out the plains and riverine parts of the Taranaki coast, Hauraki Gulf, Hawke's Bay, the Auckland Peninsula and the Bay of Plenty.

Satisfaction of the primary needs of life in the new environment stimulated experimentation and called for practical skill in using the habitat. Readjustments had to be made in clothing and shelter. The colder and more variable climate, even in the north, imposed limitations on the range of cultivation and made necessary the transformation of a year-round agricultural economy into a seasonal one.

The Seward Peninsula of Alaska. HOWARD J. CRITCHFIELD, Washington State College, Pullman.

Abstract: Seward Peninsula lies sixty miles east of Siberia and forms the westernmost projection of North America. The climate is sub-polar; its tundra vegetation grades into sparse taiga toward the east. The population is largely Eskimo. Nome, the largest settlement, is its trade center and seat of government. The region first came into prominence with the gold rush of Nome Beach at the turn of the century, and gold mining remains the leading activity. Deposits of tin near Wales and of asbestos and jade in the northeast have also been mined.

Reindeer herding was a promising industry in the past, but the herds have been seriously depleted by wolves and starvation. The Alaska Native Service plans to rebuild the herds from fewer than 2,500, their present total, to an eventual 15,000. Eskimo women make parkas, mukluks, gloves, and other clothing from reindeer hides and furs trapped locally. Trinkets carved from walrus ivory by the Eskimos are marketed from most of the villages.

Regional Diversity in Korea. SHANNON McCUNE, Colgate University, Hamilton, New York.

Abstract: Korea, though a peninsula with essential geographic unity, has within it significant regional diversity. The distribution of land forms and climatic elements results in a complexity of physical regions. Successive waves of migration of peoples and forms of culture and economy into the peninsula, followed by contrasting regional developments and by invasions and dynastic changes, have occasioned regional diversity in the distribution of population and economy. This diversity is exemplified by the patterns of political provinces and geographic regions in the country. Though the Japanese exercised strong control during recent decades, this regional diversity persisted. In some modern economic aspects, regional specialization was intensified under Japanese rule. In the present post-war period, Korea has been divided by the hastily chosen parallel of 38 degrees into zones occupied by the United States and the Soviet Union, in which contrasting political and economic developments are taking place. Thus the regional diversity of the country is being accentuated.

Air Transportation in the Far East. G. ETZEL PEARCY, Trans-World Airlines, Kansas City, Missouri.

Abstract: At the close of the second world war, the global pattern of commercial air transportation began to advance from its status at the end of the nineteen-thirties. Some 225 air lines now stretch across the continents and span several expanses of ocean. Along the eastern periphery of Asia, however, and especially in the Japanese islands, development has to date lagged noticeably.

Before the war and early in the Pacific phase of the war, Japanese air transportation flashed forth to cover and dominate a large sector of the Far East. Even though military in purpose, planes of the Japan Air Transport winged their way thousands of miles from Tokyo to areas of imperial interest. A defeated Japan has necessarily ceased opera-

tion of these routes, and until the present air transportation comparable with that available in the rest of the world (except possibly Germany) has not filled the void.

As a gateway to Asia, as Britain is to Europe, Japan should logically be a focal point for a great many converging air routes. Moreover, as an archipelago, the Japanese islands can benefit from domestic routes. Today's trends elsewhere in the world will in time inevitably encompass Japan.

Geography in Far-Western Institutions of Higher Learning. OTIS W. FREEMAN, Eastern Washington College of Education, Cheney.

Abstract: This survey includes some 191 institutions of higher learning in the eleven westernmost states of the Union. Of this number, 14 are major universities, 74 are colleges and minor universities, 22 are colleges of education, and 81 are junior colleges. About one in six of these institutions offer enough geography for a major or minor in the subject for the degree of Bachelor of Arts, although sixty percent give at least one course in geography. Where only one title is listed, it is either economic geography or a required course for teachers. In 1947-48, 30 institutions gave sufficient work for an undergraduate major or minor in geography. These included 10 major universities, 8 colleges and minor universities, and 12 colleges of education.

The Ph.D. in Geography can be earned at three universities: the University of California, Berkeley; the University of California, Los Angeles; and the University of Washington. Twenty doctorates in geography have been awarded at the University of California, Berkeley, seven at the University of Washington. The University of California, Los Angeles, has not yet given a doctorate in geography, but now has candidates for the degree. In addition to the three institutions that are authorized to give the doctorate, the University of Colorado, the University of Oregon, and Brigham Young University have awarded the degree of Master of Arts in geography. By the end of 1947, Masters' degrees in geography had been granted as follows: University of California, Berkeley, 36; University of Washington, 36; University of California, Los Angeles, 18; University of Colorado, 19; Brigham Young University, 3, The number granted at the University of Oregon can not be ascertained, since the work is given in a department of geology and geography, and the registrar was unable to separate the degrees in the two subjects.

(This paper has been published in full in *School Science and Mathematics*, vol. 48, pp. 697-704, 1949.)

SATURDAY FORENOON, JUNE 26:

Excursion in the San Francisco Bay area: the East Bay. Leaders, John E. Kesseli and James J. Parsons, University of California, Berkeley.

SATURDAY AFTERNOON, JUNE 26:

Excursion in the San Francisco Bay area: the San Francisco Peninsula. Leader, Walter Hacker, San Francisco State College.

INCREASE IN DUES

At the business meeting of the Association on June 25, 1948, Article III of the constitution was amended, by vote of the members present, to raise the annual dues from $2.00 to $3.00, beginning with the year 1948-1949.

Abridged Report of the Secretary-Treasurer

As of June 20, 1948, the membership of the Association was 145. This number represents an increase of 34 during the year.

The printing of volume 9 of the *Yearbook* cost $287.24, to which should be added $20.55 for cuts. A news letter was issued at a cost of $38.00. Postage amounted to $21.00, and miscellaneous expenses to $23.00. Total expenses were $390.69.

Income from dues was $161.00; from gifts $3.00. Sale of the *Yearbook* brought in $49.00, and royalties from "The Pacific Northwest" $90.00. Total income was $303.00. The bank balance on June 1, 1948, was $398.44, compared with $486.13 a year earlier.

Otis W. Freeman, Secretary-Treasurer

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